Eleventh Year of Service

RADIO ENGINEERING

VOL. XI JANUARY 1931 NO. 1

IN THIS ISSUE

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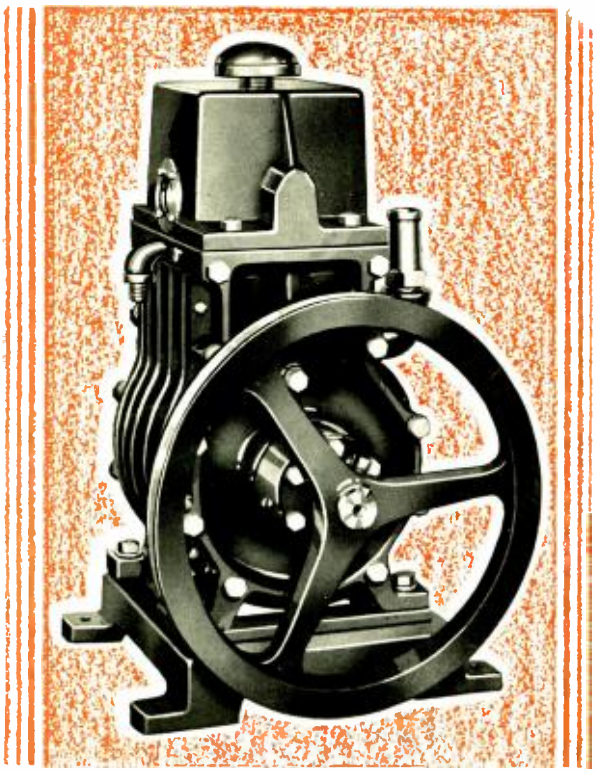
The Journal of the Radio Industry

4 new principles in vacuum pump design



The CENCO-HYPERVAC pump sets a new record for both speed and thoroughness of exhaustion - using new design principles to attain high speed exhaust to 0.05 micron pressure-

CENTRAL SCIENTIFIC COMPANY
CENCO HIGH VACUUM PUMPS
Hyvac Megavac Super vac Rotovac Hypervac
NEW YORK - BOSTON - CHICAGO - TORONTO - LOS ANGELES

The Cenco Hypervac has a high speed preliminary roughing stage followed by a precisely ground, rotary high vacuum finishing stage. Instant reduction to safe working pressures is accomplished by the large capacity preliminary stage . . . and the finishing stage follows with the finest cleanup of residual air yet attained. In this way line and tube pressures are brought almost immediately to the hundredths micron region.

Time formerly wasted in eliminating air from oil is all saved in the Hypervac by the automatic pre-rectification of oil in the roughing stage, where its effect is negligible.

The already high efficiency of the Cenco rotary finishing unit is still further increased by complete vacuum sealing of the finishing stage.

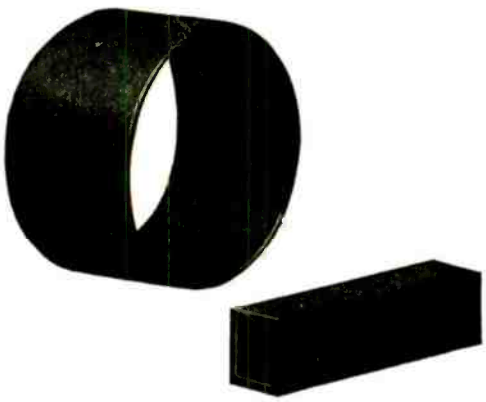
The Cenco Hypervac, even with its immensely greater load of work in a given time, runs cooler than previous oil pumps because of its principle of radiating through the pump shell. Both vacuum and service life are improved by its cooler operating temperature.

Cenco Hypervac pumps are waiting to reduce your per tube production costs this season and to improve their quality.

Ask for specifications and prices.

18 YEARS

OF SPECIALIZATION



brought HIGH Quality!

LONG effort by a competent organization developing, by the use of the most complete and modern facilities in its industry, the qualities of just one material has produced in Formica an insulator of high and uniform quality.

During the past year large additions have been made to floor space and equipment to provide the electrical and radio industries additional facilities when they shall be needed.

Good material. Quick service. Accurate fabrication. Formica has all of those to offer.

Send your blue prints for quotations.

THE FORMICA INSULATION COMPANY
4638 Spring Grove Avenue, Cincinnati, Ohio.

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RADIO ENGINEERING

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Editor DONALD MCNICOL

Managing Editor F. WALEN

Vol. XI JANUARY, 1931 Number 1

Contents

Departments

ESTABLISHED STANDARDS OF LIVING WILL DEMAND QUALITY MERCHANDISE

By A. Atwater Kent

NINETEEN-THIRTY has been a year fraught with difficulties for the commercial world. No country has escaped the consequences of an optimism that ran beyond sound business judgment. The United States in its commercial strength, however, is not suffering severely by comparison with the rest of the world, but it is hard to make many appreciate that fact. One proof is that only one-fourth as many people are unemployed as in the 1921 depression.

My own belief in the high standard of living in America will prompt me to continue our policy of making only quality merchandise. My opinion that sound business ethics will obtain in this business as it does in others causes me to express confidence in our merchandising and manufacturing methods. That sound economic practices will endure over temporary expediencies is also my belief.

It has not been my custom to make premature announcements and I will not do so at this time. I will say, however, that the future of radio looks good to me. It is predicated on our ability to make quality merchandise as wisely and as cheaply as anyone in the radio industry who practices sound and enduring business principles. When history is written it will be found that only companies who had the moral strength to build for a permanent future will be present.

BRYAN S. DAVIS
President

JAS. A. WALKER
Secretary

Published Monthly by

Bryan Davis Publishing Co., Inc.
52 Vanderbilt Ave.
New York City

Publication Office—North Broadway, Albany, New York
Chicago Office—333 N. Michigan Ave.—Charles H. Farrell, Mgr.
Cleveland Office—10515 Wilbur Avenue—James C. Munn, Mgr.
St. Louis Office—505 Star Building—F. J. Wright
Kansas City Office—306 Coca Cola Building—R. W. Mitchell
San Francisco Office—318 Kohl Bldg.—R. J. Birch
Los Angeles Office—846 S. Broadway—R. J. Birch

E. M. BACON
Advertising Manager

J. E. NIELSEN
Circulation Manager

Entered as second class matter at the post office at Albany, N. Y., January 9, 1925, under the act of March 3, 1879.

Yearly subscription rate $2.00 in U. S. and Canada; $3.00 in foreign countries.

NEW STANDARDS OF ACCURACY AND PERFORMANCE *in these* PRECISION WIRE WOUND RESISTORS

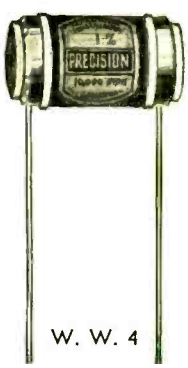
ON THE SURFACE—wire wound resistors may all appear alike—but in *performance* the difference is marked.

To meet the most exacting requirements for accurate, dependable resistors for many uses, the International Resistance Company has developed a complete range of Precision Wire Wound units.

The same engineering skill and thoroughness which have placed *Metallized* Resistors made by this company in the lead in the radio field, have given to these new Wire Wound Resistors distinctive advantages possessed by no others on the market.

In the *winding,* in the *wire and its treatment,* and in the *contact,* weaknesses common to the ordinary wire wound resistor have been positively eliminated. A folder describing these features and quoting prices and ranges will be mailed on request.

INTERNATIONAL RESISTANCE COMPANY
2006 Chestnut Street, Philadelphia



W. W. 4


W. W. 3

W. W. 1

W. W. 2

I. R. C.
Metallized
Resistors are acknowledged the best for radio manufacture. I. R. C. Wire Wound units set the same standards of excellence.

I. R. C.
PRECISION
wire wound
RESISTORS

Editorial

January, 1931

AN RMA SHOW IN 1931

THOSE who attended the RMA show at Atlantic City, in June, 1930, who also visited the mechanical industries show in New York, in November, last, had the opportunity to visualize a noteworthy change of the times.

At the mechanical show manufacturing executives themselves, sales managers and engineering experts, of the respective exhibitors, were present in the booths continuously. Conservative, sane business exploitation was in evidence on all sides. All ballyhoo and all pajama-maiden methods of sales promotion were plainly non-existent. The bulk of the mechanical show was at the Auditorium, not in hotel suites.

The radio industry will do well to follow the example set by an older and more seasoned industry. The 1931 convention and trade show of the RMA, to be held, probably in a mid-west city, in June, next, will present new opportunities for all radio manufacturers who desire that their organizations be recognized as legitimate units of a great industry.

The RMA is officered by competent, experienced manufacturing, sales and engineering executives—men whose desires are to contribute surely toward the success of all units of the industry. In the RMA, every manufacturer of complete receivers and every manufacturer of accessories has an always approachable source of council and of aid in those problems which soon or late are discovered to be common to all manufacturing enterprises.

▲

HIGH POWER BROADCASTING

IT appears that the seventy-five kilowatt new broadcasting station located at Muhlacker, Germany, now operating on 360 meters, the channel formerly occupied by Stuttgart, is spilling over disagreeably into neighboring countries.

The channel separation of the German station from the London, England, Regional broadcast station is nine kilocycles. Since November 21, last, when Muhlacker went on the air, it is reported that broadcast listeners in London are experiencing much difficulty in hearing their own station without interference.

The subject is interesting in view of the present agitation in the United States for largely increased powers for about twenty broadcast stations. Of course there are many variables. Each broadcast station once established is a sheaf of laws unto itself. Also, many will say that the English listeners will have to look closer to selective properties of receivers they purchase.

▲

READY FOR A NEW START

A REVIEW of the condition of the manufacturing industries at the end of 1930, discloses that radio stands well up from the bottom on the list of those that weathered the storm. The year 1930 witnessed drastic readjustments which cannot fail to have a beneficial effect upon future manufacturing and merchandizing.

The purchases of parts and accessories during 1930 were confined strictly to what was necessary for the makeup of sets for the existing 1930 market. This leaves a nearly clear field for 1931. The most dependable information obtainable indicates that at the end of 1930, warehouse inventories were by far less burdensome than were the inventories at the beginning of the year.

There are wide differences of opinion as to whether the advent of the midget receivers was a blessing or the reverse. Viewpoint appears to have been largely a matter of inventories of other and more complete lines of receivers. Manufacturers having in stock or in production larger models capable of high grade reproduction naturally deplored the exploitation of the midget.

However, manufacturers not committed to the merchandizing of receivers mounted in the furniture of 1928, were in positions to take on the midget and make money from the venture. Indeed, while some of the long established radio manufacturers had rough going, a considerable number of new companies entered the field and because of the hard times demand for inexpensive receivers, plus the condition that they had no hold-over obligations at the banks, were able to show reasonable profits on 1930 sales.

In the matter of models no doubt there will be cycles of popularity for particular styles for some years to come.

There never has been a period, prosperous or depressed, when there was not opportunity for ingenuity.

A year from now it will be known approximately what the gross sales for 1931 total. It behooves every manufacturer to think straight, to analyze, to anticipate sanely, so that 1931 will in part at least make up for the headache of 1930.

Donald McNicol

Editor.

Self-tapping Screws *HOLD BETTER*

Comparative laboratory tests conducted by unbiased authorities prove that Hardened Self-tapping Sheet Metal Screws make better fastenings than machine screws or bolts and nuts. Practical demonstrations of this fact are found in hundreds of assemblies subjected to severe stresses of tension, shear and vibration.

"But Why does this Screw hold better?", an engineer will often ask. It is a natural question. A Screw that forms a thread in sheet iron, steel, aluminum and Bakelite as it is turned into an untapped hole, is revolutionary in principle. Such simplicity has not been associated with the making of secure fastenings.

The microscope shows why a Self-tapping Screw holds better under vibration, the chief cause of fastening failure. Remembering that the security of a fastening under vibration depends upon how tightly the Screw threads are engaged in the metal, look at the unretouched microphotographs here. It is easy to see why the Self-tapping Screw holds better.

Its threads are so firmly embedded in the metal that screw and metal are practically one. But between the machine screw threads and the tapped threads (commercial tolerance) there is considerable space . . . space which permits the screw to loosen under vibration.

Under stresses of tension and shear, a stronger fastening is obtained with the Self-tapping Screw because it possesses greater tensile strength than ordinary screws, being made of a special steel, scientifically treated.

It is obvious that the extreme simplicity and ease of making fastenings with these unique Screws must result in great economy of assembly time and labor. Where these Screws are used there is no costly tapping or tapping troubles. No fumbling with bolts and nuts either. Elimination of such fastening difficulties has resulted in large savings by thousands of users of Self-tapping Screws

Parker-Kalon Corp., Dept. L, 190-193 Varick St., New York.

More Facts in these two Free booklets!

Proof of Economy

PARKER-KALON
HARDENED SELF-TAPPING
Sheet Metal Screws

Proof of Security

In each of 22 major cities — a complete headquarters for electrical wire products

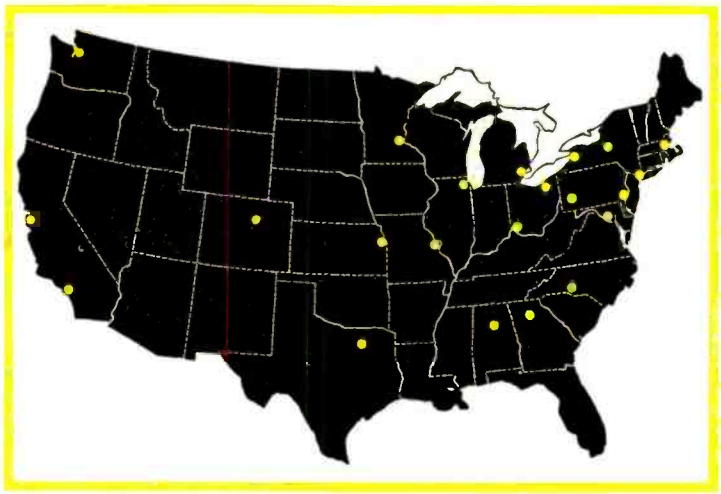
GENERAL CABLE CORPORATION simplifies purchasing for the radio industry, by concentrating in a single source the manufacture and sale of an immense variety of wires, coils and assemblies.

In the past, your purchases of the products of each component company of General Cable were made through independent sales staffs selling only the products of their own plants. General Cable unifies the entire sales structure.

All representatives — themselves technically competent — now present ALL the products of ALL the twelve General Cable plants. So from any of the twenty-two District Offices you are now offered any electrical wire product — whatever your requirements.

These General Cable representatives bring you the assistance of a unified engineering staff and greatly augmented research

GENERAL CABLE



laboratory facilities. They present the widest variety of conductor materials available — with unprejudiced recommendations for specific applications. They also offer you the advantages of a widespread warehouse system, for prompt delivery of those products customarily carried in stock.

These twenty-two District Offices — each of which is General Cable Headquarters for sales and engineering service — are located in the leading industrial centers of America, for your convenience. Wherever your factory may be, one of these offices is practically around the corner.

DISTRICT OFFICES

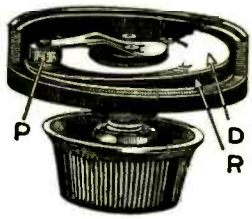
ATLANTA 1526 Healy Bldg.			PITTSBURGH 1814 Kappers Bldg.
BIRMINGHAM 1306 Watts Bldg.	CINCINNATI 920 C. of C. Bldg.	KANSAS CITY Board of Trade Bldg	ROME, N.Y. Mill St.
BOSTON 89 Broad St.	CLEVELAND 1814 Terminal Tower	LOS ANGELES 939 East Fourth St.	SAN FRANCISCO 465 Tenth St.
BUFFALO 56 Clyde Ave.	DALLAS 1614 Allen Bldg.	MINNEAPOLIS 109 So. Seventh St.	SEATTLE 570 First Ave. South
CHARLOTTE 501 First Nat. Bank Bldg.	DENVER 650 Seventeenth St.	NEW YORK 420 Lexington Ave.	ST. LOUIS 1213 Ambas'dor Bldg.
CHICAGO 20 No. Wacker Drive	DETROIT 827 Fisher Bldg.	PHILADELPHIA 123 South Broad St.	WASHINGTON 704 Wilkins Bldg.

PLANTS

BALTIMORE Maryland	DETROIT Michigan	MOBILE Alabama	PERTH AMBOY New Jersey
BAYONNE New Jersey	EMERYVILLE California	PAWTUCKET Rhode Island	ROME New York
BUFFALO New York	FORT WAYNE Indiana	PENNINGTON New Jersey	ST. LOUIS Missouri

CORPORATION

when Death gambles with Control



This shows the exclusive rocking disc construction of Centralab volume control. "R" is the resistance. Contact disc "D" has only a rocking action on the resistance. Pressure arm "P" together with shaft and bushing is fully insulated.

THE white-robed surgeon, from the moment his knife is poised, never dares to lose Control as the whole operating structure functions smoothly under his watchful eye. Slovenly technique on the part of even the "scrub nurse" may spell Death.

Every phase of the building of a Centralab resistance unit must be under control if it is to function accurately, smoothly and noiselessly.

That twenty millions of Centralab controls have been sold all over the world attests to the perfection of this technique.

Centralab

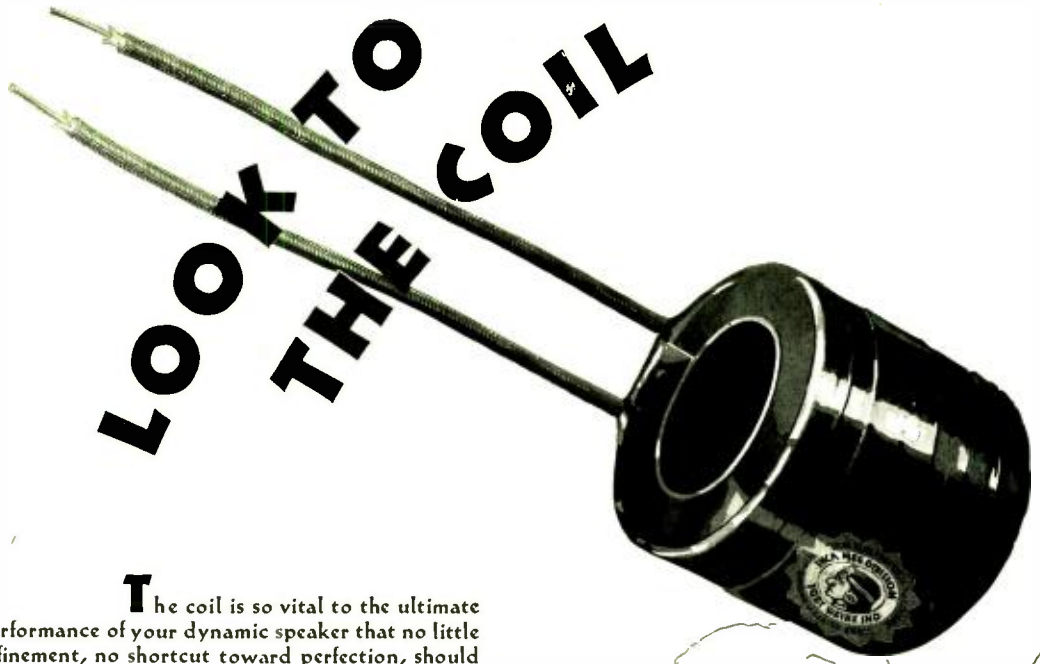
CENTRAL RADIO LABORATORIES

Dept. 212B, 28 Keefe Ave., Milwaukee, Wis.

Send 25c
for the new
Volume Control Guide

Just off the press showing resistance circuits on most all old and new sets. Service them with a mere handful of CENTRALAB Controls.

LOOK TO THE COIL



The coil is so vital to the ultimate performance of your dynamic speaker that no little refinement, no shortcut toward perfection, should be overlooked.

The Inca dynamic field coil shown above is wound from the finest grade of enamel wire, thoroughly tested, with the result that short circuited turns are reduced to a surprising minimum. Unusual, too, is the very small variation in resistance.

A special terminal anchorage, developed by Inca (patent applied for), holds leads so securely that they will stand the stress of the severest treatment ever met in any assembly line.

Inca coils are treated with a special compound which forms an impervious sheath, providing high insulating properties and effective prevention against moisture, as well as mechanical protection.

And finally, rigid tests for each electrical characteristic and modern methods of packing insure the faithful performance of every Inca coil.

A sample of this, or any other Inca coil you may require, will be wound to your specifications upon request, without obligation.

Look to Inca for the solution of your coil problems.

The Inca Indians were mining copper and working it into useful objects while North America was yet a wilderness. They combined copper with tin to form bronze . . . an alloy which the marauding Spaniards falsely concluded to be the "lost secret" of tempering copper.

INCA MANUFACTURING DIVISION

of NATIONAL ELECTRIC PRODUCTS CORPORATION

FORT WAYNE, INDIANA

Symbolic of the best in copper wire products.

Eastern Office: Newark, N. J., Industrial Office Building.

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FANSTEEL

now offers

TUNGSTEN

IN ALL COMMERCIAL FORMS

ADJUSTMENT of former patent restrictions now permits Fansteel to offer 99.95% pure Tungsten, in rod, sheet, wire and ribbon. Several Tungsten alloys are also available.

Fansteel, of course, has been refining pure Tungsten since 1914, but only for use in electric contact points. Now manufacturers using other forms of Tungsten are to have the benefit of Fansteel's experience, and equipment for working rare metals. Unusual purity, uniformity, and workability are characteristic of Fansteel Tungsten.

Send for a sample in the form in which you wish to use it. Note its accuracy of dimension. Give it a fair trial and note its performance. You'll like it—and the price is right! Tungsten, like other Fansteel metals and alloys, is stocked in all standard sizes and shapes to insure prompt deliveries.

Write for samples and prices.

FANSTEEL PRODUCTS COMPANY, Inc.
NORTH CHICAGO, ILLINOIS

TANTALUM · TUNGSTEN · MOLYBDENUM · CAESIUM · RUBIDIUM · ALLOYS

Clarostat Automatic Line Voltage Regulator (Plug-in Type)

10,000 hours of actual operation!

BACK in 1929 several Clarostat Line Ballasts, picked at random from stock, were started off on a life test. They are still going strong after over 10,000 hours of actual operation under gruelling line voltage changes.

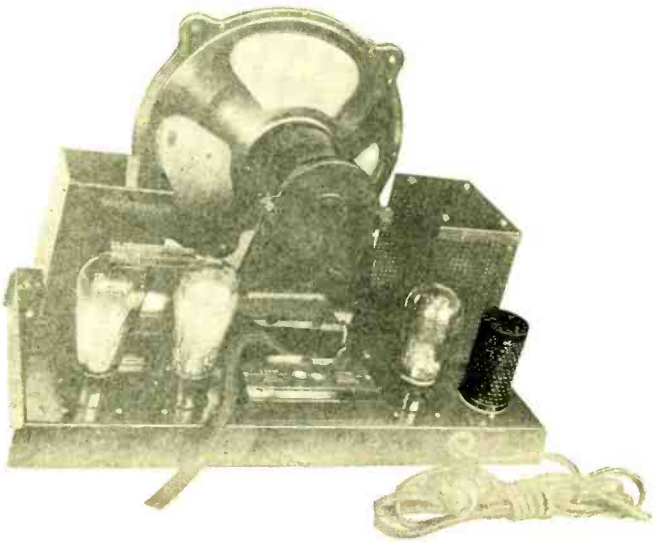
The current has been turned off and on periodically, the voltage has risen to over 140 and dropped below 90 and still these Ballasts maintain their full original regulating abilities.

Similar tests made by nationally known set manufacturers in their own laboratories have only confirmed the durability and protective qualities of the Clarostat Line Ballasts.

By designing a receiver for use with a Clarostat Line Ballast, protection from both low and high voltages is assured.

For sets already built there is the Clarostat Automatic Line Voltage Regulator, a plug-in device which automatically protects against high line voltages.

Be Prepared. 1931 will be a Voltage Regulator Year —The Screen Grid Year has passed, the Tone Control Year is now in progress and the Voltage Regulator Year is just ahead.



GREBE SK-4 Power Pack equipped with Clarostat Line Ballast

CLAROSTAT is ready with two types of time tested regulators.

1. The Clarostat Line Ballast engineered to match your transformer, a built-in feature which protects on low lines as well as on high lines. Automatic and instantaneous.
2. The Clarostat Automatic Line Voltage Regulator, an accessory to plug in between the line and the radio. Automatic protection against high line voltages.

BULLETINS on Voltage Regulators, Volume Controls, Rheostats and other resistance devices may be had on request.

CLAROSTAT MFG. CO. 285-287 N. 6TH ST. BKLYN. N.Y.

Impressions and Expressions

By AUSTIN C. LESCARBOURA

ELECTRICAL TRANSCRIPTIONS

IN the scheme of broadcasting, electrical transcriptions or specially recorded programs have evidently found a permanent place. We note the growing use of electrical transcriptions not only by the smaller stations but also by the largest stations generally identified with wire network programs. Also, we note several large program producers turning to electrical transcriptions as a means of securing greater distribution for programs at a lower cost to sponsors or to sustainers.

Properly recorded, the electrical transcription is by no means objectionable, even in direct contrast with the finest studio programs. The Chevrolet Chronicles hour now on the air is a splendid example of electrical transcription at its best.

As we view electrical transcription development, we are moved by two serious thoughts: first, we believe the development is splendid for the smaller, independent stations, for it tends to pull them up to the proper entertainment level. This is particularly desirable in many sections of our country not over-served by good stations. Secondly, we hope electrical transcriptions will not grow to the point of replacing the wire network, for the latter must be maintained for the spontaneous news features so vital to the continued popularity of broadcasting. Let us hope that electrical transcription will do the job for the smaller and the independent stations, but that it will not overdo the job to the detriment of the network institution.

▲

RUMORS

THE radio industry has always been renowned for its rumors. But during the past few months, perhaps with nothing better to do, the radio industry has greatly increased its output of rumors until practically every organization is the victim of all kinds of wild tales which do no particular good.

A favorite rumor is that this, that or the other company is going broke. Imagine the effect of such a rumor on the sales, public acceptance and general credit rating of any organization. And when such an organization comes to be examined critically, we usually find that it discounts all its bills and has a handsome cash balance on hand.

And when the rumor does not concern the threatened bankruptcy of the organization, it has to do with the contemplated firing of some of its highest executives. Many of our radio leaders have been fired a dozen times by the rumor-mongers during the past few months. The fact that several of the highest officials in the field have been dispensed with has been so much fuel for the fire.

While we are trying to get this radio mess of ours straightened out for 1931, let's take a wallop at our rumor-mongers. They are doing all of us no particular good and, indeed, much harm.

▲

MENTAL DEPRESSION

IMAGINE a thriving radio plant; a tiny office crammed full of clerks, busily entering orders and counting the money; a small store crowded with buyers and clerks; a steady flow of cases going out to waiting trucks; a string of salesmen waiting to tell their story—sounds like 1924 or 1925 radio days, does it not? Yet this is a picture the writer recently enjoyed, right in New York City, and in fact right around the corner from some of the leaders of the radio industry who bemoan the lack of business.

The secret of the picture just painted is *head work*. The little concern, which has just completed the greatest year of its career, is using its head. Every month, several new items are introduced. Most of them are accessories—something which the average public cannot help buying. There is a steady production on all items that sell steadily. Those that do not sell are set aside. Sales and production functions are very closely coordinated, so that no dumping is necessary.

After all, there is much mental depression or recession to this industry of ours. Many of us have lost the fine art of using our heads. We lack originality. We do not study buying trends. We do not diversify our lines. We pay no attention to accessories. We separate research, engineering, production and merchandising by such wide gaps that each function is a thing apart, making for a very weak commercial structure.

Let's snap out of our mental depression! Let's begin using our heads! There is a market—for brains.

▲

DIVERSIFICATION

WE have just completed the shortest season of the radio industry. Some component manufacturers have worked just exactly six weeks, turning out their orders for the set manufacturers. Once more, many plants are practically closed down or, at best, operating with a small skeleton force.

We cannot go on like this. We must operate at least six months out of the year, and that is bad enough. We must diversify or find other products to make in our plants. Obviously, there is not enough market to keep all our radio plants going on the usual run of radio equipment, unless we can sell the last Chinese coolie, the last African Hottentot and the last Hindu.

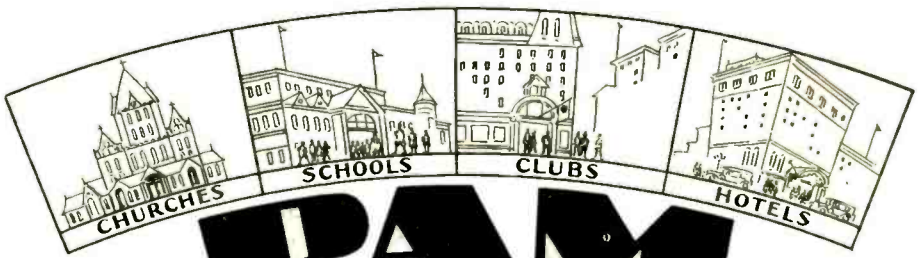
Already the radio manufacturers are stepping out of their original roles. Several are making electrical refrigerators. The rumor now going the rounds is that a leading radio manufacturer is contemplating a line of electrical refrigerators. Some are considering electric or synchronous clocks. Some have tried electric motors and motor-driven appliances. Others have essayed trick refrigerators, furnace controls, photocell devices and other oddities.

During the coming months, we hope to present some real constructive material on diversification. Since much of this work is being done under cover, much of our reporting will be of a speculative rather than on a factual basis.

▲

THAT MIDGET SET ALIBI

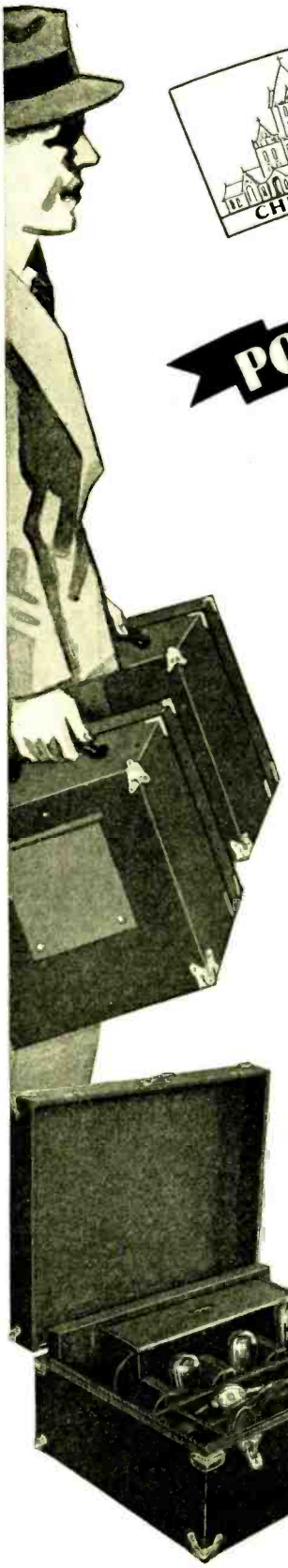
SALES being decidedly off color in the radio set game, alibis are now in order. And the most handy alibi these days is the midget radio set. Big manufacturers are laying all the blame for their lack of prospective sales to the tiny radio sets which have killed the market, so we are told.



PAM

PORTABLE ADDRESS SYSTEM

quickly Pays for Itself



Schools, churches, clubs, hotels need the portable PAM Address system. With it, a speaker addresses 500 people as easily as half a dozen. Speech and music, both vocal and instrumental, are amplified with excellent quality.

The units in this system are completely matched and designed to operate together. Naturally the results obtained are superior to a combination of units procured from different sources which were not designed to operate together.

The two units that are required (MIK 100 and PAM 100) together weigh less than 75 pounds, and the system can be set up ready for use in less than five minutes. No batteries are required . . . and the price complete with tubes, microphone, etc., and nothing left to buy, is $343.00.

Send for twin folders RE1; one descriptive of the PAM-100 and the other of the MIK-100.

SELL

Portable PAM Address system to institutions that hold regular meetings and need the equipment permanently. This price is reasonable and the profits are large.

RENT

Portable PAM Address systems for special occasions. One man can transport the entire system and set it up in five minutes. After a few rentals the cost is recovered and future income is all profit.

Main Office:
Canton, Mass.

Samson Electric Co.

MANUFACTURERS SINCE 1882

MEMBER RMA

Factories: Canton and Watertown, Mass.

RADIO ENGINEERING

Production, Administration, Engineering, Servicing

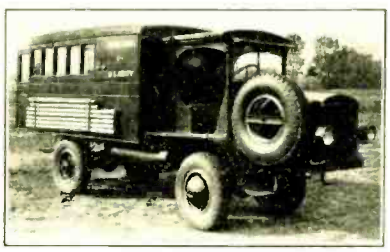
JANUARY, 1931

Signal Corps Motorized Radio Equipment†

By Carter W. Clarke*

SIGNAL CORPS engineers have developed and have ready for use in the field a mobile radio set which appears to be the last word in motorized radio equipment. This set which is known as the Mobile SCR 132 Radio Set was designed and built to keep apace of the modern trend toward mechanization and extreme mobility in a modern army.

The SCR 132 set is a ground telephone and telegraph set, intended for telephone communication up to 100 miles with an airplane set known as the SCR 135 mounted in a bombing plane. The telephone range with another ground set would be considerably greater than 100 miles. The transmitter of this set operates over a wave frequency band of 150 to 350 kilocycles while the receiver will operate over a band of 100 to 1000 kilocycles. The receiving equipment is intended for telephone, modulated c.w. telegraph and c.w. telegraph reception.



All actual transmitting and receiving equipment is contained in this large van.

The most interesting feature of this set is the motor equipment which consists of a four-ton, four-wheel drive truck and a three-ton gas electric truck. These trucks designed especially for the Signal Corps are a radical departure from standard practice in motor truck construction.

The gas-electric truck carries a large motor-generator set which furnishes power for the radio transmitter mounted in the larger truck. A power take-off receptacle, cable and the necessary controls are provided for the purpose of connecting the two trucks electrically.

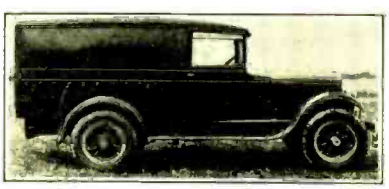
Method of Propulsion

The mechanical construction and general appearance of this truck are similar to the ordinary motor truck. It differs chiefly in its "drive" or method of propulsion, which is both mechanical and electrical in nature. A direct-current, shunt generator is attached to the engine crankshaft. This generator is electrically connected to a series motor, which in turn is mechanically connected through a universal to a drive shaft.

The control of this equipment is simple in nature and is conveniently placed with respect to the driver's seat. The controller lever has four marked positions, namely, "neutral," "forward," "brake," and "reverse." It is provided with a magnetic interlock which is placed in the ignition system. When the ignition switch is turned on an audible click may be heard, thereby indicating free control lever action.

With the control lever in the "neutral" position, the output of the generator and the motor field are disconnected. In the "forward" position the output of the generator is connected to the motor, and the motor series field is connected to its armature. The "brake" position of the controller lever reverses the series field of the motor and inserts a grid resistance in series with it. The controller lever in the "reverse" position reverses the motor series and short circuits the grid resistance.

Only by actually operating this truck can one appreciate its extreme flexibility. It has a specified speed range of from three to forty miles an hour. These various speeds are obtained without shock or jar by a simple movement of a foot switch. The extreme low speed range of this truck permits



Small truck which carries generating equipment, and is linked with conveyor by means of a high tension cable.

† *Published by permission of Major General George S. Gibbs, Chief Signal Officer, U. S. Army.*

* *First Lieutenant, Signal Corps, U. S. Army.*

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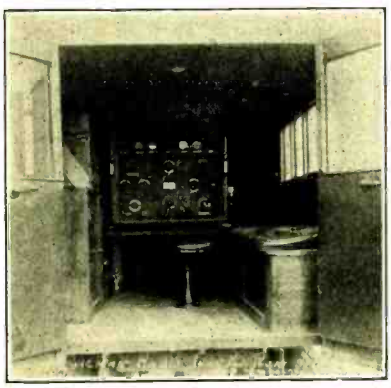
Description of a Flexible Mobile Installation for Radio Telegraphy and Radio Telephony

it to follow in the rear of a column of marching troops without the usual ill effects due to over-heating.

Drive Control

The gas engine of the truck is started in the usual manner with the controller lever in the "neutral" position. The car is placed in motion by placing the controller lever in the position desired and then operating the foot switch. The car will gradually accelerate until the desired speed is reached. This speed is maintained by the proper manipulation of the foot switch.

Additional tractive power on a steep grade is obtained by the operation of what is known as an accelerator switch. Closing this switch energizes the "teaser" field of the shunt generator. This acts as a booster to the output of the generator.



Interior of truck showing installation of apparatus. The set has a telegraph range of 1,000 miles.

Three means are provided for braking the car when going down grade, namely, the dynamic brake (marked "brake" on the controller), the foot brake and the emergency brake. These latter two are similar to those found in any commercial motor truck and are used when it is desired to bring the truck to a dead stop. The dynamic brake, however, is utilized by placing the controller in the position marked "brake." As has been stated, this reverses the series field of the motor and places a grid resistance in series with it. The grid resistance prevents an excessive current from flowing through the series field.

The braking effect is obtained by the force due to the series field tending to turn the motor armature in the opposite direction to its normal direction of rotation. Consequently, if the engine speed is increased a greater braking effect will be obtained due to the increase in electric current in the series field of the motor. This braking effect will hold the car at the safe speed of fifteen miles an hour on a steep grade. It would seem that this is a most unusual car if accelerating the engine will have the effect of either increasing or decreasing the speed of the car, depending on the will of the driver.

Trucks Connected Electrically

When it is desired to operate the radio transmitter carried in the large truck the two trucks are connected electrically by a ten-conductor weatherproof cable sixty feet in length. This cable has plugs on each end and is plugged into the receptacles provided for this purpose on each truck.

In utilizing the power take-off of this truck the controller lever is placed in the "neutral" position, the switches on the control panel operated and the speed of the engine gradually increased by means of the hand throttle mounted on the steering post. This places in operation the motor-generator mounted inside the truck for the purpose of supplying the high-voltage necessary to operate the radio transmitter. The gas engine is provided with a governor for the purpose of maintaining a constant speed when using the power take-off feature.

The large truck in which is mounted the radio transmitting and receiving equipment also carries the antenna and counterpoise equipment and mast sections necessary to place the set in operation. The chassis of this truck is standard construction but the body and mountings were designed and built especially for the Signal Corps.

In addition to the four-wheel drive feature this truck is equipped with extra large pneumatic tires. These special features are necessitated by the fact that almost invariably it will be found advisable to move the truck some distance off roads and across country before the radio set is placed in operation. Extensive experiments have shown that more satisfactory results can be obtained with a truck constructed along these lines than with one of the type ordinarily employed in commercial practice.

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CIRCUIT CONTROL BY MEANS OF PHOTOTUBES

PHOTOELECTRIC control equipment has now been developed to a point where its position in the industrial field is definitely established. It offers a means of solving some of the problems for which no satisfactory equipment has been available heretofore, and also of simplifying some of the processes now in use.

The industrial application of photoelectric equipment progressed sufficiently to warrant the establishment of a line of photoelectric devices and accessories.

Both alternating-current and direct-current photoelectric relays were applied to many problems in which the interception or application of a beam of light is used to control an electric circuit; *e.g.*, the operation of a magnetic counter, stopping and starting machines, operation of deflector mechanisms on conveyor systems, safety devices, starting or stopping operations on articles that are too small, too light, or too delicate to operate a mechanical limit switch. The ability of these control devices to operate from the interception of a beam of light offers a valuable new tool to industry.

Photoelectric tube and amplifier devices provided with terminals for connection to an indicating or recording instrument are now used in making simple comparative measurements of illumination intensities and reflecting powers, and in investigations to determine the feasibility of adapting photoelectric equipment to the solution of the more difficult problems.

One relaying device of the General Electric company incorporates a photoelectric tube, Pliotron tube, and Thyratron tube. Because of its high speed of operation and large current output this device has been found very useful because small colenoids, contactors magnetic counters, etc., may be connected directly in the output circuit of the Thyratron tube and controlled without the use of an intervening relay, with its inevitable time lag.

The light sources for use with the photoelectric equipments are compact units employing a low-voltage concentrated-filament lamp and a plano-convex lens in such a manner as to provide an approximately parallel beam of light sufficient to operate the photoelectric relay at a distance of 25 feet.

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DECEMBER SALES INCREASED BY RMA PROMOTIONS

RADIO sales in December, during the pre-Christmas drive, were materially promoted by two efforts of the Radio Manufacturers Association which secured wide cooperation of broadcast stations, jobbers and dealers.

Every day for several weeks before the holidays, according to reports received by Bond Geddes, executive vice-president of the RMA, a large number of broadcast stations broadcast announcements urging the public to buy modern radio. Radio jobbers and dealers also used the big broadcast features, such as the Army-Navy football game, the international broadcast of the Prince of Wales and Mussolini, and similar events in their advertising, and newspapers also used the outstanding broadcast features in the advertising of holiday radio.

These sales promotion efforts in the pre-holiday campaign were made at the request of the RMA and received widespread and even enthusiastic cooperation from the broadcast stations and the radio trade, whose trade papers also assisted in the holiday merchandising campaign.

Modulated Continuous Waves and the Stenode Radiostat

By C. H. W. NASON

An Engineering Discussion of the Theory of a New Receiver System Recently Brought From England and Demonstrated in New York

RECENT claims regarding systems of transmission and reception of modulated waves might lead one to believe that the basic engineering and physical concepts relating to these subjects were at fault. The facts, however, lead to a directly opposing conclusion—to wit: that the fundamental concepts are not only free from fault but are strengthened in their position by a careful physical or mathematical perusal of the argument.

With particular reference to the falling off of the higher modulation frequencies in tuned circuits a perusal of the theory will offer two explanations. One based on the popular "sideband" principle and the other on the premise of "decrement." It makes no difference which of these approaches is taken—the arithmetical result being the same in either case.

During the past season engineers on this side of the Atlantic have been treated to the din of distant combat while Sir Ambrose Fleming—called into consultation by the Baird interests—strove to dictate a theorem whereby all reasons for excluding television from the broadcast band of frequencies might be dissolved. Startling the engineering world with the pronouncement that the "sideband" theory of the structure of a modulated wave was a mathematical fiction evolved by none too erudite engineers as a tool for calculations, Sir Ambrose in an article appearing in *Nature* likens the sidebands unto the proverbial "black hat." It is not the purpose of this writer to argue the debate for either side—nor would it be in particularly good taste to refer one's readers to Sir Ambrose's comparatively recent and most excellent text, "The Propagation of Electric Currents" for an elaborate proof of the "sideband" premise. It is no matter to be taken lightly—this refutation of the pronouncements of an international authority—and yet a thousand odd competent radio engineers will tell you that they not only believe in the existence of the harmonic components as physical entities but have measured them readily with a good wavemeter. A reasonable investigator can come to but one conclusion when all the facts are before him—namely, that as a debater Sir Ambrose is a fine engineer. It might be remarked in passing that certain of the Bell Laboratories engineers must be quite startled to realize that for several years they have been conserving considerable "ether" and still more considerable power by shooting telephone conversations across the seas by virtue of an isolated sideband which does not exist.

On the crest of their debate the British engineers were startled by the advent of a novel reception process devised by Dr. James Robinson for which certain unusual claims were made. For example it was claimed that two carriers having equal field intensities at the receiving point and no more than one thousand cycles separated could be readily received without mutual interference. This without any effect upon the modulation frequencies up to five thousand cycles. Here was a direct refutation of the "sideband" theory.

Amplitude Variation

Consider what goes on in the tank circuit of a radio transmitter when the microphone is spoken into. A carrier wave having a frequency of oscillation f is being emitted at a constant amplitude. The effect of the microphone when its diaphragm is acted upon by a sound wave having frequency f′ is to periodically vary the amplitude of the carrier as shown in Fig. 1. The factor m is used to denote the depth to which the amplitude of the carrier is varied. If m is unity the amplitude variation is such that the carrier swings from zero to twice its normal value during each alternation of the modulating frequency after the fashion shown graphically in Fig. 1B. When such are the conditions the wave is said to be completely modulated and a 100 per cent modulated carrier results.

Mathematically the carrier can be represented by the equation

$$I\,(1 + m \cos 2\pi f't) \sin 2\pi ft$$

which by simple trigonometry becomes

$$I\left(\sin 2\pi ft + \frac{m}{2}\sin (2\pi f + 2\pi f')\,t + \frac{m}{2}\sin (2\pi f - 2\pi f')\,t\right)$$

which shows that three frequencies exist, f (the carrier frequency), $f - f'$ (the lower sideband), and $f + f'$ (the upper sideband). Where the modulation is complex the two side frequencies vary and occupy a range on either side of the carrier frequency, dependent upon the highest modulation frequency present. It is this transformation that prompts questioning.

Fortunately for the defendants, the mathematical "artifice" works both ways. One may plot the curve for the equation

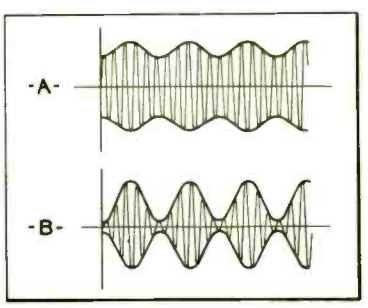

Figure 1.

$$i = I\,(1 + m \cos 2\pi f't) \sin 2\pi ft$$

$$i = \left(\sin \pi ft + \frac{m}{2} \sin (2\pi f + 2\pi f')\, t + \right.$$

and for

$$\left. \frac{m}{2} \sin (2\pi f - 2\pi f)\, t \right)$$

and find that they are identical. Not only this but one may set up an oscillator modulated at any particular frequency and by the aid of a wavemeter pick off the three frequencies, f, $f - f'$ and $f + f'$. The experiment is quite reversible in the sense that three oscillators may be set up emitting the three frequencies named in their proper relation as to amplitude, and obtain the physical equivalent of the modulated wave indicated by the equations presented.

Now this seems to be a case entirely for the mathematical physicist. We can analyze a modulated carrier into three distinct components by a simple trigonometric transposition and we can build up the modulated wave from the three components thus obtained by a physical synthesis. These facts are readily verified by practical measurement.

A Factor of Selectivity

The phenomenon of sideband cutting in a highly selective receiver is known to all experimenters and has been explained on the basis of lack of sufficient "broadness" of tuning, time and again. This explanation is based on the resonance curve of the tuning circuits in combination as applied to the sideband theory. The relative response at various frequencies removed from the true resonant frequency of a tuned circuit is shown in Figure 2B. The resulting attenuation of the higher modulation frequencies is obvious from the figure. The so-called band-pass arrangement of two coupled circuits is shown in Fig. 2B and is also self explantory as far as the betterment of high frequency response is concerned.

If two carriers are but slightly removed one from the other and are both impressed upon the radio-frequency circuits of the receiver an audio-frequency beat will result which, rectified, gives rise to the familiar and annoying heterodyne whistle. The two

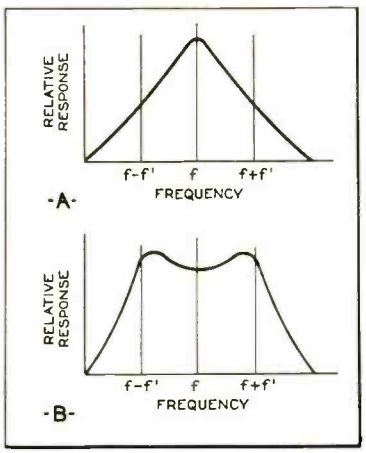

Figure 2.

carriers beating thus give rise to the already familiar sum and difference frequencies—the difference being within the audible range. The original carrier frequencies are still present as will be seen later.

The gentleman mentioned early in this discussion neglected to call attention to these last facts, regarding ability to detect the sidebands by actual measurement.

There is another fact just as firmly grounded in physical existence which is often neglected in discussing the action of radio systems—that is, that any phenomenon explainable through recourse to the "carrier and two sideband" theory is as readily explainable by treating the circuit as being acted upon by a single frequency of varying amplitude. It is unfortunate that the latter conception has fallen into the discard in elementary discussion—it has its uses as has the sideband method. Naturally, when considering the circuits in the light of electric-filter theory with a view to establishing a band-pass condition with rapid cut-off in transmission to each side of a chosen band, ten kilocycles in width, we are limited to the use of the more familiar theory.

Let us consider a simple tuned circuit similar to the one already employed in visualizing the effect of sideband cutting and shown in Fig. 2A. Instead of accepting the existence of the side frequencies we may visualize this circuit as being acted upon by a voltage of fixed frequency but of rapidly varying amplitude. If an alternating current is impressed upon this circuit the current will decrease at a rate dependent upon the relation between resistance and reactance in the circuit.

Coils for example having a high value of Q' (WL/R) have a low decrement and the current in the circuit will decrease slowly. Since the low decrement circuit is thus less susceptible to change the higher frequency variations in amplitude will have less effect than the lower frequency changes and a consequent attenuation of the higher frequencies of modulation will result.

Here then we have accounted for one phenomenon of the tuned circuit without recourse to the sideband theory and there is no reason why circuits entirely independent of the sideband treatment can not be designed.

One thought still remains: that is, that we must not lose track of the fact that a circuit having sufficiently high decrement to allow for the retention of the higher frequencies also is broad in tuning and will accept undesired carriers unless a sharp cut-off in the resonance curve is provided. Here a viscious circle presents itself, as without some band-pass effect we cannot have the sharp cutoff without a circuit of low decrement and attendant distortion.

In December, 1929, publicity with reference to the remarkable invention of Dr. James Robinson, a British scientist, was presented to radio engineers. Engineers of the highest repute, accustomed to dealing with circuit theory from the "sideband" point of view only, were frankly and sharply skeptical. The claims made for this system were little short of astounding, and the most remarkable part of it all is that within the past few months, since further research has placed the equipment on a firmer footing, these claims have been made good. A feature of the device is that stations having carrier frequencies differing by but a few hundred cycles may be tuned separately without heterodyne interference. Naturally, an acceptance of these facts as a standard of operation is questionable, as any attempt to crowd more stations into an already overcrowded broadcast spectrum must await the development of other circuits of excellence in so far as selectivity is concerned.

The Circuit Arrangement

Reference to the schematic circuit of Fig. 3 yields little other than the fact that a superheterodyne arrangement of rather normal aspect is employed. As far as it goes that is true. The difference in the Robinson invention lies in the input to the second de-

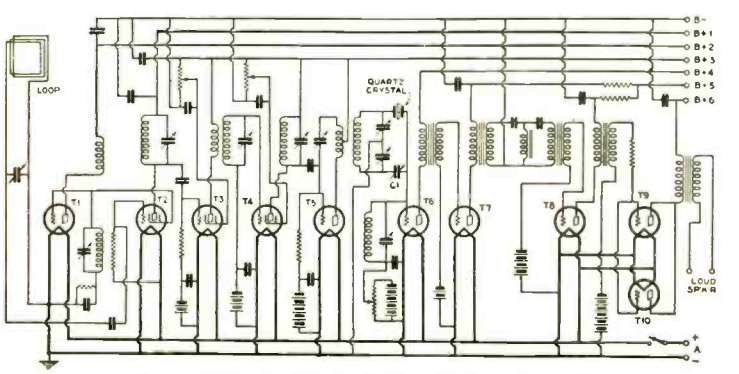

Fig. 3. Theoretical circuits of the Stenode radio receiver.

tector. The transfer of voltage from the plate circuit of the last intermediate stage to the grid of the second detector is through a quartz resonator ground to a frequency within the range of the intermediate frequency amplifier. This circuit may be as sharp as desired and consequently a considerable amount of amplification ahead of the crystal is obtainable.

The three condensers shown in conjunction with the crystal constitute a capacitance bridge by means of which the capacity of the crystal holder may be balanced out of the circuit. With the crystal out of its mounting and the bridge unbalanced the circuit behaves in the same manner as the superheterodyne of everyday practice. It is necessary in order to obtain the benefits of the system to balance the bridge so that no voltage transfer is developed. After this adjustment has been effected the crystal may be inserted in its mount with full assurance that any voltage transferred to the grid of the second detector is due to piezoelectric vibration of the crystal itself. Inasmuch as these oscillations can only occur at the natural frequency of the crystal it may be assumed that the desired frequency alone —and modulated only as to amplitude —will appear at the output of the capacitance bridge.

The premise of "decrement" must now be interpreted so as to account for the attenuation of the higher frequencies. The decrement of the crystal is extremely low and consequently the circuit will not respond to the higher frequency variations in amplitude in the same fashion as to the lower modulation frequencies. In order to avoid this effect so far as possible we must employ the highest possible intermediate frequency as the loss in response is a function of both the decrement and the natural period of the circuit. In order to compensate for this attenuation a simple high-pass filter section is interposed between the detector and the first stage of audio-frequency amplification.

Limited Usefulness

The circuit is of little use where the transmitter shows effects of "frequency modulation" and consequently only crystal controlled transmitters of good design may be received. In transmission circuits where the crystal stage is not sufficiently isolated from the modulated circuit a degree of reaction occurs in the crystal oscillator circuit which tends to shift the frequency slightly. This is hardly noticeable with receivers of normal characteristics but is fatal to reception in the case of the *Stenode Radiostat*. This fact points to an explanation of the immunity of the circuit to the effect of heterodyning interference may possibly be obtained by reference again to the "sideband" interpretation. This phase of the theoretical analysis is due to a prominent British engineer, S. O. Pearson.

By modulating the amplitude of a particular carrier the resulting wave may be analyzed into three components of *constant* amplitude and frequency. Such an analysis cannot be made with less than three component frequencies. In the case of heterodyne interference there are two oscillations from which to obtain a mathematical synthesis. In such a case the resultant is not of constant frequency and has no effect upon the crystal. These facts may be demonstrated in a satisfactory manner by simple mathematics.

Without actual laboratory experience with the circuit it is difficult to comment on this view. It is the writer's opinion that the freedom from interference found will not be explained through this varying frequency premise taken by Mr. Pearson but that it may be found that the phasing of the various components constituting heterodyne interference will give the final explanation. In the meantime the publicity given the new circuit has served a good purpose in stimulating engineering thought along new or long neglected lines. The receiver has its main advantages today under such conditions as exist in Europe where the allocation of frequencies is an international problem not controllable by legislative enactment in the United States. There are also evidences of its value in multiplex telegraphic work.

Radio Advances in 1930

General Electric Company Engineers Note Year's Progress

A POWER amplifier nominally rated 10 kw. and a suitable rectifier were developed to permit an increase of the output of existing low-power stations. Two UV-858 tubes are used as linear amplifiers in a push-pull circuit. These operate normally with 18,000 volts obtained from the rectifier.

An improved design of 5-kw. transmitter was produced and a number were placed in operation. The main improvements provided a higher degree of frequency precision and stability, and reduced the harmonic radiation to a minimum.

A low-power transmitter rated 100 watts to cover the broadcast band was developed in which crystal control and four-element tubes were used to insure extremely good frequency stability. Complete modulation is obtainable which produces peak power output of 400 watts. A modulation indicator is provided to enable the operator to obtain the best possible performance from the equipment.

For use in connection with sound pick-up of events occurring outside of broadcasting studios, a portable amplifier was produced. This class of apparatus is subject to rough usage and, for this reason, the design incorporates features that several years of experience have shown to be necessary for reliable performance.

For installation in broadcasting studios, a variety of amplifying, monitoring, switching, and other forms of control units are required. A new line of these units was introduced during the year. An improved design of condenser microphone stand was also developed.

Developmental Transmitting Station

Major accomplishments were in connection with providing increased output from the various broadcasting transmitters. Transmitter W2XAG was operated regularly for a considerable period of time at 200-kw. normal output on WGY's regular wavelength of 379.5 meters. The peak power when fully modulated was 800 kw. The output stage of this transmitter contains six UV-862 water-cooled tubes each nominally rated at 100 kw. High-voltage direct-current for this amplifier was obtained from a hot-cathode-type rectifier nominally rated 750 kw. This accomplishment provides the basis for the design of broadcasting transmitters of still higher ratings.

Transmitter W2XAF was operated on its regular wavelength of 31.48 meters with an output of 25 kw. fully modulated ; peak power 100 kw. Six UV-858 short-wave tubes are used in the final amplifier stage.

A Superheterodyne Receiver for Short Waves

By R. WILLIAM TANNER

Description of an Oscillator Tuned System for High Frequency Radio Reception, Giving Stable Operation.

THE superheterodyne type of receiver is sensitive and selective in the reception of short waves. This is especially true below 100 meters where even screen-grid tubes show low efficiency as radio-frequency amplifiers.

There are, however, a number of disadvantages, the most annoying of these probably being the "two-spot" bugaboo, so common to all double-detection circuits. This article is not intended to be a theoretical discussion but instead, a practical one. Therefore, suffice it to say that all superheterodynes can bring in a station at two settings on the oscillator dial. The number of dial degrees between the two settings depends upon the value of the intermediate frequency.

Some designers get around this by peaking the intermediate frequency amplifier at some frequency above 1500 kc., which proves very satisfactory providing the frequency coverage of the tuning circuits does not exceed twice the intermediate frequency; such a condition never being attained in commercial receivers.

If a very low capacity oscillator condenser is employed to give a frequency coverage of, let us say 3000 kc. (twice the intermediate frequency) in the 20-meter band and, incidentally, comparatively easy tuning, this size would be far too small for the waves above 70 meters, as well as requiring a large number of plug-in coils. On the other hand, if a tuning condenser is used to give comfortable tuning on the higher waves and a coverage of 3000 kc., "one-spot" tuning is no longer a feature on the low waves. The result is confusion particularly to those not understanding the principles of the superheterodyne.

Like all other types of short-wave receivers, tuning is extremely critical on the lower bands when the same condenser is used to cover the entire short-wave spectrum. There seems to be no such a thing as a "happy medium" in this case. Plug-in tuning condensers have been used but the disadvantage of this is quite apparent.

The inherent broadness of the first detector tuning is considered by some to be an advantage but such is not the case. Even though the intermediate frequency is of a high value, a strong signal will force itself through on the second beat and cause interference. This is easily understood when it is considered that only one tuned circuit is interposed between the antenna and grid circuit of the first detector. Of course tuned radio-frequency stages or tuned circuits in the form of a band-pass filter may be connected ahead of the first detector but this offers many difficulties from the constructional standpoint.

Regeneration Objectionable

If broadcast or radiophone signals are desired, good tone quality is necessary. The use of a biased second detector is then as essential as a biased power audio amplifier. Few designers of short-wave receivers take this into consideration. They undoubtedly are thinking in terms of regeneration and low sensitivity such as that obtained with the usual form of tuned r-f. tuners and assume that the operator will pick up the carrier squeal of a station before bringing in the voice or music. Nothing could be further from the truth with a well designed and constructed superheterodyne. Regeneration has no place in this part of a modern high-quality short-wave super.

In addition to these disadvantages there is the effect of interlocking of tuning controls which is always present when any method of inductive coupling between the oscillator and first detector is employed. This effect manifests itself by the detector tuning being as critical as that of the oscillator and each reacting upon the other. By employing a screen-grid or space-charge first detector and feeding the oscillator energy from the plate through a resistor to the extra grid of the detector, this effect is at a minimum. Since the voltage on the extra grid must be at a definite value for highest sensitivity this method sometimes requires a juggling of the oscillator plate voltage as well as an adjustment of the coupling resistor.

Let us see how we can correct these disadvantages. Since the oscillator is the direct cause of the "two-spot" annoyance, why not employ a *fixed tune* oscillator and do all of the tuning with a variable intermediate frequency amplifier in conjunction with the first detector condenser?

Experiments towards this end over a period of twelve months have definitely proven that this method is not only desirable but practical as well. Not only is the second beat eliminated but tuning is no more critical at 20 meters than at 100, the intermediate-frequency amplifier tuning covering the same frequency range regardless of the wavelength of the incoming signal. The importance of this is readily apparent to those who have explored among the short-wave channels.

By designing the intermediate-frequency stages to cover a band from

approximately 100 to 300 meters, the frequency coverage will then be 2000 kc. allowing extremely easy tuning. A standard, gauged .00035 mfd. condenser will just about cover this range.

Two Screen-Grid Stages

In order to provide fairly uniform gain, the i-f. transformers will require comparatively large primaries which brings up the question of selectivity. At least two screen-grid stages are necessary to give sufficient gain for loud-speaker reception on distant stations. However, the number of tuned circuits associated with two stages is insufficient to give proper selectivity when the transformer primaries are large. The addition of another tuned i-f. stage or a band-pass filter may be employed, the latter being the most desirable from the viewpoint of cost.

Greater care than usual must be taken in the shielding of the i-f. stages to prevent feedback since screen-grid tubes become rather unstable as the frequency is increased above 1500 kc. It will probably be necessary to run the plate and grid leads from the tube sockets to the transformers in metal tubing in order to completely eliminate oscillation. De-coupling resistors in both the B positive and screen-grid leads seems to be more effective in eliminating coupling through the B supply than regular r-f. chokes in the individual leads.

High capacity by-pass condensers are not at all necessary. The small types having a value of .006 mfd. are sufficient. Due to their stacked plate construction inductive effect is negligible.

By this time some readers may have begun to wonder how a fixed oscillator can be employed to cover the waves between about 16 and 100 meters. To be exact, the oscillator is semi-variable, the adjustment being set once for each band of wavelengths and not varied while tuning.

Variable Inductor Employed

The oscillator tuning circuit will have to cover a range of slightly under 6000 kc. to about 21,000 kc. (The i-f. tuned circuits should not come too close to the minimum frequency of the short-wave circuits.) The complete range may be covered by means of a variable inductor (variometer) mounted on the same shaft as the tuning condenser.

Any oscillator tuned circuit is comparatively stable when the shunt capacity is high. Therefore, a variable condenser with a maximum of .00025 mfd. can be used in conjunction with a small variometer. A vernier dial for this unit would be unnecessary, one of bakelite 2 inches in diameter serving the purpose nicely.

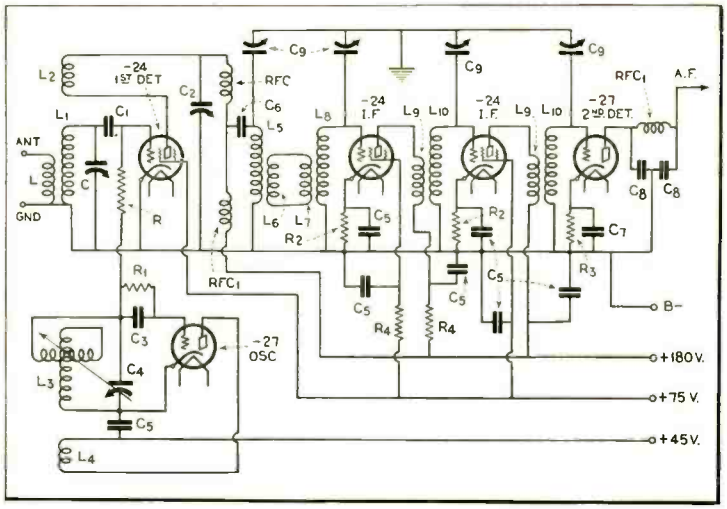

Fig. 1. Circuit elements of an efficient superheterodyne receiver for short-wave working.

The design of the variometer is not difficult. The inductance range should be as great as possible. The plate coil may be wound at one end of the stator, the coupling varying as the inductance of the variometer is changed. The number of turns in the plate winding and the separation from the stator will require some experimenting to provide stable operation throughout the entire tuning range.

Broadness of tuning in the first detector can be cured either by tuned r-f. amplifiers or by means of regeneration in the first detector. (Regeneration at this point cannot effect tone quality unless carried to extremes where side-bands are clipped.) The degree of selectivity in this part of the super does not have to be 10 kc. In fact if it were tuning would be far too critical. From 25 to 50 kc. separation will effectively prevent signals coming in on the second beat frequency.

The use of regeneration is the simplest and least expensive means of providing sufficiently sharp tuning of the first detector. Generally, while tuning, the regeneration control can be set a few degrees below the point of oscillation and not require constant adjustment. Sensitivity is also increased materially.

The first detector coils may be of the plug-in or tapped type whichever is desired.

A biased second detector for this type of super will offer no difficulties to the designer as this is a well understood subject.

Interlocking of tuning controls, while not serious in the Tanner short-wave super, can be reduced to practically zero by feeding the oscillator energy to the first detector grid through the detector grid leak. This method seems to give somewhat better results than feeding to the detector screen grid. The leak is not at all critical.

A schematic circuit of this very efficient short-wave super is shown in Fig. 1. No audio amplifier is shown as nearly every designer has his own preference. However the new Tanner system is recommended since audio howling and motor-boating is practically absent. This system was developed especially for short-wave receivers, a description of which appeared in the July 1930 issue of RADIO ENGINEERING.

The writer will be glad to answer any questions regarding this new superheterodyne upon receipt of a stamped, self-addressed envelope.

RADIO DOCTORS PLAN TUBE HOSPITAL

PLANS for a radio tube "hospital," a technical clinic for the study of disease of the vacuum tube, have been made by the Radio Manufacturers Association. While most radio tubes have a life of a thousand or more broadcasting hours, the radio doctors will study measures to extend even this amazing mortality rate. The clinic for radio tubes is under the direction of George Lewis of Newark, N. J., chairman of the vacuum tube committee of the Radio Manufacturers Association, and in immediate charge of George Rishell of Emporium, Pa., chairman of the subcommittee in charge of "life testing" of tubes. The manufacturers' clinic is preparing a list of diseases of the vacuum tube for laboratory diagnosis. When a radio tube dies the radio scientist is as much interested in this fatality as a medical scientist is interested in a human demise. The radio doctors expect to discover means to prolong the useful and vigorous life of the radio tube.

A Magnetically Operated A-C. Voltage Control Device

By J. G. SOLA *

A Nearly Horizontal Value of Supply Voltage is Desirable in Radio Receiver Operation

WHEN the a-c. receiver was introduced it became evident that a means to control the line voltage fluctuation was an essential for perfect reception and for saving on replacement and repair costs.

The two best known methods heretofore used to control this fluctuation have been the ballast resistor arrangements and taps on the primaries of the power transformer.

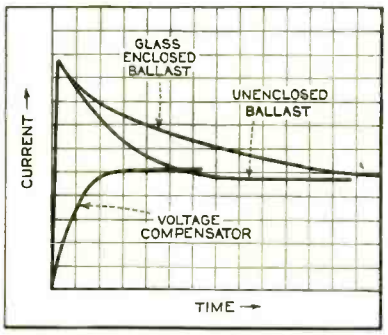

Fig. 6. Time-current relationship on starting.

In the opinion of the writer disadvantages of the ballast resistor type are: first, inherent sluggish action that permits high currents at momentary voltage overloads, and high and prolonged starting currents. Ballast resistor regulators with any degree of regulation can not be used in a set without a special low voltage primary power transformer, and then they introduce a 40- to 85-watt loss, which is far from economical.

The use of a tapped primary for voltage control is based upon the assumption that line voltages are consistently high, medium or low—a condition seldom met with.

The voltage compensator here described is entirely magnetic in operation, giving instantaneous control; that control necessary for the elimination of high current overloads caused by momentary voltage surges and high starting currents. The efficiency of the transfer to a regulated supply is quite high, the core loss of the compensator being only 14 watts.

Theory of Operation

From the dimensions of the core illustrated in Fig. 1, it is evident that the core sections C will be but one-third the area of section A. Therefore, up to the saturation point these sections C will operate at three times the density of section A. A very small portion of the total flux will be forced through section B due to high reluctance caused by the air gap in its circuit.

With an input of 80 volts to a loaded compensator the core sections C are just starting to work at a saturating flux. Therefore since a part of the magnetic circuit is saturated the wave shape of the output voltage and current will be formed into a peaked wave; that is, peaked in proportion to the saturation of the compensator core sections C, as shown by the oscillograms in Figs. 2, 3 and 4. In this group of oscillograms are included the voltage waveforms with a pure resistive load, and a transformer load of a standard radio set. Numbers 2 to 4 being the resistive loaded and numbers 5 to 7 the transformer loaded, Number 1 is the sinusoidal voltage input to the compensator. Since the current waveform with the pure resistive load follows in form that of the voltage, only the waveforms of the output current when supplying the transformer load are shown, these being numbers 9 to 11. Number 8 is the sinusoidal current input to the compensator.

The peaks of the various voltage waves were measured using a peak reading voltmeter.

With the same radio set as a load that

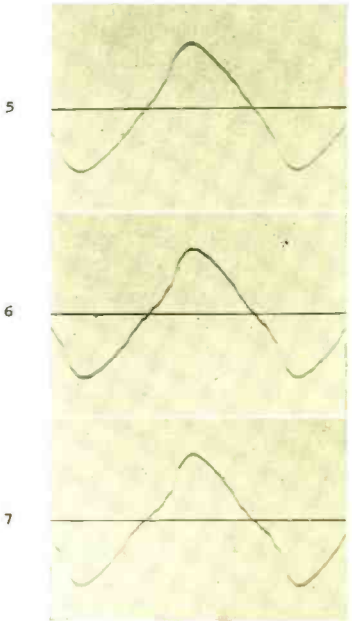

Fig. 3. Voltage Curves.
5. 90 volts input
6. 110 volts input
7. 130 volts input

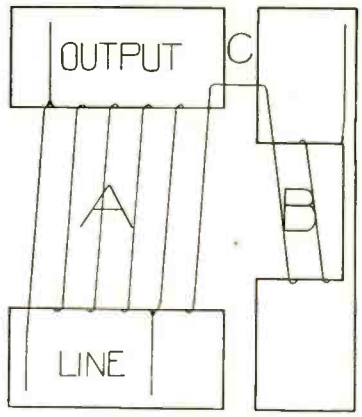

Fig. 1. Basic design used in construction of Sola compensator.

* Chief Engineer, Sola Corporation.

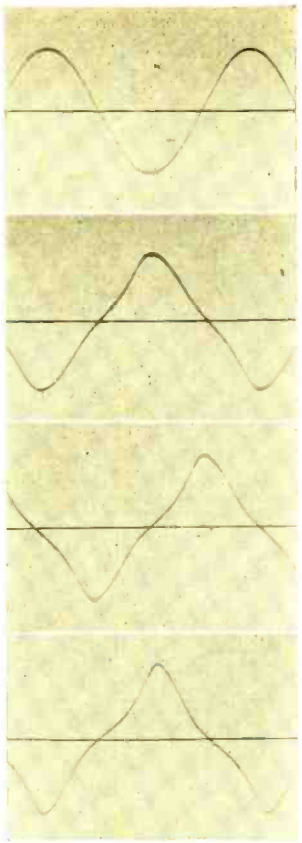

Fig. 2. Voltage Curves.
1, Sinusoidal input voltage
2, 90 volts input
3, 110 volts input
4, 130 volts input

was used when taking the oscillograms, the peak measured, with a 90-volt input to the compensator, was 21 per cent higher than that of a sine wave of the same root mean square value. For 110 volts input, 30 per cent higher and for 130 volts input, 34 per cent higher.

The Regulation

Regulation is a controllable feature so that if it is necessary, or more adaptable, a compensator with a greater degree of regulation can be designed and manufactured, manufacturing costs being only slightly higher for better regulation. For the standard radio set, a regulation of 50 per cent was found to be a balance between the cost and the necessary regulation required for the best operation of the set. The standard compensator has been made with this amount of regulation.

Whether an inductive or a resistive load is applied to the compensator the regulation curve does not alter appreciably. This is due to the fact that the angle of lag of the reactive component becomes less for a resistive load.

Some interesting curves of the regulation within the standard set used for most of the tests are shown in Fig 5. These are regulation curves on the 2.5 volt and 5.0 volt filament tubes and the a-c. per plate of the rectifier with and without a compensator supplying the set. On the last, notice that the safety limit given by the manufacturer is exceeded without the compensator, but the voltage is kept within narrow limits when it is used.

Unlike other magnetic and thermal regulators that have been developed the voltage compensator here considered gives a regulation that is only slightly changed with varying loads.

Advantages

Since the voltage and current output is of a peaked waveform, the core loss, and therefore the heat, of the power transformer being supplied by a compensator will be less because the peaked voltage wave gives a flat topped wave of magnetism, and thereby transforms the voltage with a lesser maximum magnetic flux, than a sine wave of the same effective value; that is, the same power. As the hysteresis loss depends on the maximum value of the magnetic flux, the reduction of the maximum value of the magnetic flux, due to a peaked voltage wave, results in a *lower* hysteresis loss and thus a higher efficiency of transformation. On standard radio transformers the core loss is reduced 25 per cent, affording quite a saving to the manufacturer wishing to take advantage of this fact.

Since the d-c. voltage output from a rectifier is approximately proportional to the peak voltage applied, it is obvious that, the d-c. voltage output will be higher when supplying the set with the output from a compensator than when a sine wave supply is used. This increase is 25 per cent. A saving may be effected on the power transformer due to this.

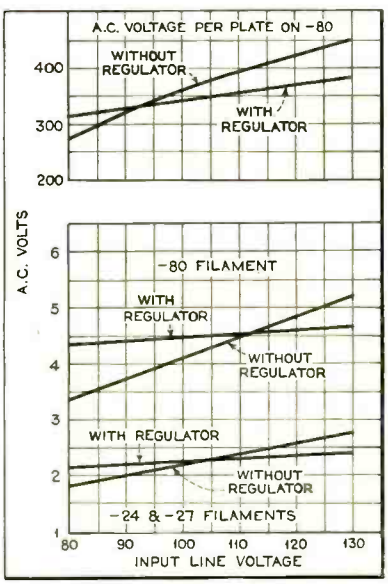

Fig. 5. Regulation within the set using voltage compensator.

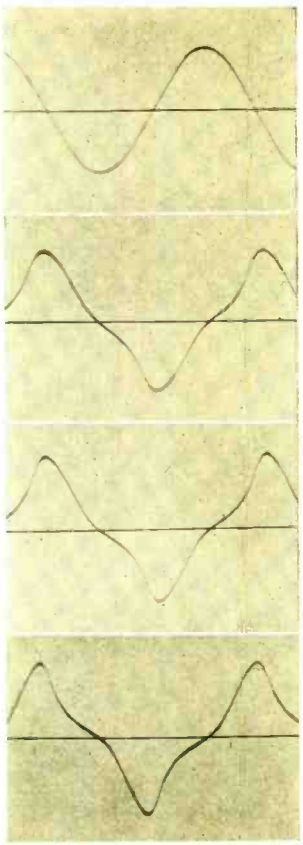

Fig. 4. Current Curves.
8, Sinusoidal input current
9, 90 volts input
10, 110 volts input
11, 130 volts input

The a-c. component of the d-c. output or hum is not increased when using a compensator.

Due to its construction the voltage compensator, unlike thermal regulators, is everlasting and unbreakable, a feature not to be overlooked.

Since the regulation is due to magnetic rather than thermal conditions the compensator delivers an instantaneously controlled regulation. Also there is no high starting current as is the case in a thermal regulator. Fig. 6 illustrates the starting currents of the glass enclosed and unenclosed thermal regulators, as against the starting current of the compensator, all reduced to the same proportions for better illustration.

From the manufacturer's standpoint, the use of the voltage compensator not only effects a saving but gives the best regulator with more advantages than any other type offered.

To the set owner it offers complete protection and a saving on replacements and servicing.

Short-Wave Receiver Design

By A. BINNEWEG, JR.

CONSIDERABLE has been written on the subject of short-wave receiver design, but little of this has been of much value to the engineer. Published measurements on practical arrangements have been surprisingly few in number. The short-wave regenerative detector has been widely exploited in the past few years. Some of the more technical aspects of short-wave receiver design, with experimental results, are here considered. With slight changes in circuit constants, operation is greatly improved.

IN the operation of short-wave receivers, it is desirable that the regeneration control shall have a minimum effect on the frequency of the secondary tuned-circuit. Some engineers prefer resistance control of regeneration as it has somewhat less detuning effect than other methods. Resistance control of regeneration has also its disadvantages, however. In some arrangements of resistance control, a drop in plate voltage results so that the detector plate voltage must be increased to the proper operating point. This is not particularly objectionable if the set is operated from socket power. This mode of control is not entirely independent of frequency as the feedback automatically increases as the frequency is increased, and a change must be made in the control to compensate. Moreover, it was a real problem to obtain a variable resistor which is not noisy and which continues so. For these reasons many short-wave receivers employ a condenser for controlling regeneration.

Detuning Effect of Capacitive Control

In most present-day arrangements, a fixed tickler is used in conjunction with a variable capacity. Capacitive control of regeneration also influences the tuning, due to capacitive effects. through the tube (especially noticeable on very short wavelengths). However, by proper design it is possible to materially reduce this effect. The receiver dial can then be calibrated in frequency and the settings will remain reasonably constant. In a regenerative receiver there are other contributing factors which cause small frequency shifts in the tuning scale. For example, with worn B batteries, in the case of battery-operated sets, the plate voltage is less, requiring somewhat more capacity in the regeneration control to produce oscillations which influences to some extent the receiver calibration. Tubes in which the emission has fallen off have somewhat the same effect. Assuming that under the proper conditions the important factor which affects the receiver calibration is the regeneration control, it is obviously of the first importance to reduce this effect. This is not difficult to do.

▲

Improvement in Operation Possible by Slight Changes in Circuit Constants

An approximate equivalent circuit will be used to show how the effect of the throttle control on the resonant frequency can be reduced. In Fig. 1-A are shown the essential connections for a receiver employing capacitive control of regeneration. In Fig. 1-B the approximate equivalent circuit for Fig. 1-A is shown. The equivalent circuit shows that the grid condenser and grid-filament tube capacity are in series, this combination being in parallel with C_1, the tuning condenser. C_2 is the throttle condenser and a change in its capacity is known to influence the wavelength of the tuned circuit SC_1; the entire combination of Fig. 1-B is thus roughly equivalent to Fig. 1-C, since an increase in the capacity of C_2 results in a decreased frequency, and a decrease in C_2 in an increase in frequency of the tuned circuit. This can also be accomplished by changing the setting of an equivalent condenser C_0, in Fig. 1-C.

Tests were carried out to determine the approximate amount of detuning resulting when the grid-plate capacity of a given tube is changed, by means of a small variable condenser in parallel with this tube capacity. A shielded type —99 tube short-wave oscillator was employed to furnish a test signal. This signal was tuned in with the receiver, then the settings were adjusted until the highest audible beat-note was obtained, and with C_2, the throttle control, just at the edge of oscillation. The throttle-control setting was then changed until zero beat was passed through and highest audible beat on the other side was obtained. The difference between the two dial settings at the upper and lower limits of audibility were noted. As the value of the grid-plate capacity was increased, the throttle-control had more effect on the secondary tuned circuit as was expected. Other simple tests show that the effect of the throttle control on tuning increases greatly as the frequency is increased, with constant grid-plate capacity. This is to be expected, since, at higher frequencies, less capacity is used in the tuned circuit. Consequently any variation in the equivalent shunt arrangement has greater effect. The tube capacities become large in comparison. In this respect there is some advantage in using two tuning condensers in parallel for short-wave work. The larger of the two condensers in parallel is used for the lower frequencies, or to shift rapidly from one wave-band to another, and the smaller "vernier" for spreading the narrow bands over the entire dial width; but the regeneration-control in this arrangement may have less tuning effect.

A small tickler coil mounted inside the secondary gives less detuning when the throttle is operated. Since the grid-plate capacity has a large effect, it should be kept as small as possible. The only way to change it, internally, is by using a tube in which the capacity

is less. One immediately thinks of the screen-grid tube for this purpose. However, the comparatively large plate-to-screen capacity introduces other problems, when the screen-grid connection is employed; in general, for the space-charge connection, the results for a three-element tube apply. The three-element tube serves well as a short-wave regenerative detector and improvement in its operation will be considered. The results in general apply also to screen-grid detectors.

Throttle Control Size

The size of the throttle-control used is important. A comparatively small throttle control is not satisfactory. A throttle control should ordinarily cover a comparatively large range, as changes in the set may throw the point of oscillation outside the throttle range. A small throttle requires also a larger tickler, hence its tuning effect will be increased.

A study of the schematic diagram suggests that the size of the throttle control compared with the other capacities will have an effect on the amount of detuning under given conditions. The throttle control was shunted with various values of capacity in the special experimental set. With capacities of the order of 250 mmfd. the detuning is comparatively small.

Since it is desirable to have a small grid-plate capacity, a type —99 tube is preferable for a detector, from this viewpoint. The type —12 tube is a very good detector and which oscillates easily at even the highest frequencies. It has a comparatively large grid-plate capacity and it is usually found in sets employing resistance control of regeneration.

It is not a simple matter to obtain accurate quantitative results at short wavelengths. Some useful curves taken on a practical set are explained later.

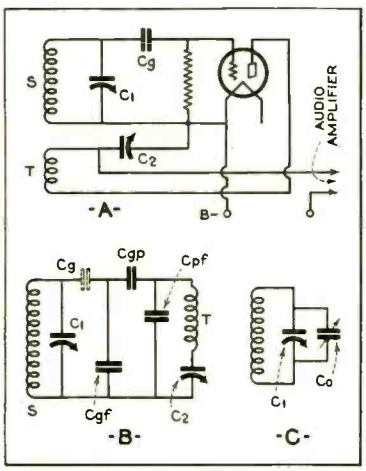

Fig. 1. The essential connections for a short-wave regenerative detector are shown at A; approximate equivalent circuits are shown at B and C.

The effective grid plate capacity can be reduced still further in the usual set by employing a short plate lead and a low-capacity socket.

A special receiver was constructed and tested. A type —99 detector was first used. It was desired to see if extra care would result in any marked improvements. The salient features of this set will appear.

It may be said to represent close to a "practical ideal" condition for a three-element tube short-wave detector circuit. One of the old Canadian "Meyers'" tubes was employed for the tests. This tube requires a special socket, but its internal capacities are smaller than those of the type —99 tube. The general construction of these tubes is not far from the ideal three-element tube for short-wave use, as the "double-end" arrangement results in very small internal capacitances. The old "Audiotron" was of the same general construction as the Meyers' tube. These tubes had a reputation among amateurs as being quite sensitive. Evidently the designers considered chiefly the technical end.

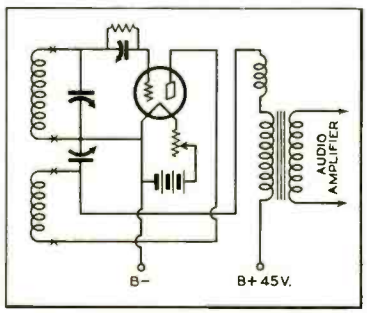

Fig. 3. Essentials of circuit tested. Tube base plug-in coils are employed.

The set employed a Meyers' tube and had short leads. Ordinary tube-base coils were employed. Various sizes of throttle controls were tested, the experimental set employed finally a 100 mmfd. midget type variable capacity. The set of curves shown in Fig. 2 were taken with this set.

In Fig. 2, "C" refers to the tuning condenser and "G" to the grid condenser which was also of 100 mmfd. maximum capacity. "C-O" on a curve means that the tuning condenser (100-degree scale) was set at minimum or at zero scale; "G-50" signifies that the grid condenser was set at 50 degrees on its 100-degree scale, etc.

Experimental Results

The uppermost curve in Fig. 2, for a grid condenser setting of "zero" (actually about 4 mmfd. minimum for this condenser alone), and with the tuning condenser set also at "zero", the detuning of the secondary circuit when the throttle is operated, between minimum and maximum setting, is rather large about 3 megacycle (300 kc.) This is small compared with the same effect in other receivers, under the same conditions.

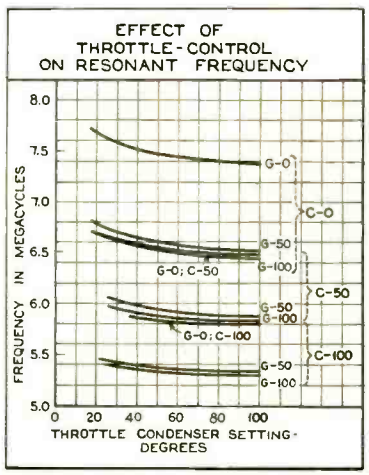

Fig. 2. Effect of capacitive regeneration control on the resonant frequency of a short-wave three-element tube detector circuit.

As the setting of the grid condenser is decreased and that of the tuning-condenser is increased, the frequency, of course, decreases but the effect of the throttle is reduced greatly. In general, as the capacity in the throttle-control is increased, the curves flatten out, showing that for larger sizes of throttle capacity the tuning effect becomes smaller. In general, with this type of tube, the throttle-control should be adjusted so that about 100 mmfd. is required at the edge of oscillation. Tests with other tubes have shown that about 150 mmfd. minimum should be used. More is desirable from this standpoint but there are limiting factors. The use of a larger capacity value allows the use of a smaller tickler size, usually.

In practice it is usually not required to operate the throttle control over its entire range. In some homemade sets, it is found often that large changes in the throttle control are required when tuning over a frequency band. One cause for this is a tickler which is too small or which is spaced too far from the secondary coil. In the set tested a change of only a few degrees of the throttle-control was required to cover the range of a four-plate midget type variable condenser, used alone, so the detuning was comparatively small. The change in the throttle for proper control will of course increase as the range covered by the secondary condenser is increased. A small midget type condenser of three plates and used alone (without shunt condenser) covers about 37.2 to 43.5 meters, here. The detuning of the secondary circuit can be made small with proper design.

(*Concluded on page 30*)

Mechanical Remote Tuning Controls for Radio Receivers

By J. C. SMACK*

Description of One Method of Solving the Problem of Remote Tuning Control for Broadcast and Airplane Radio Receivers

REMOTE tuning controls for radio receivers have come into prominence and popularity only within the last two or three years. They are divided into two general classes; those operated by mechanical means and those operated electrically. The electrical controls consist of motor driven tuners, relays, etc., having a sphere of use all their own.

There are four general classes into which the mechanical type of remote controls can be divided. These are as follows: (1) Rigid shaft with universal joints. (2) Belt, wire or cord and pulley drives. (3) Push and pull wire mechanisms, and (4) Flexible shaft drives. This article will be devoted to the specific uses and construction of remote tuning controls of the mechanical type, using a flexible shaft.

A flexible shaft remote tuning control to be used on any radio receiver must be composed of three units. These are: (1) The remote tuning dial usually of the geared vernier type. (2) Flexible shaft and casing combination of suitable length, and (3) Gear unit of proper ratio to be attached to condenser shaft. Due engineering consideration must be given to the proper design of each of these units in order that they will work satisfactorily together, also the unit as a whole must be designed for the particular tuner to which it is to be attached.

Engineer, Industrial Division, The S. S. White Dental Mfg. Co.

Fig. 1. General construction of flexible shaft.

It might be well at this point to explain the construction of flexible shafts. All sizes of shafts are made up of a number of layers of steel wire wound alternately in opposite directions. Various grades are manufactured in each diameter, the principal differences of which are the sizes and number of layers of wire used and the manner of winding same. The general construction of a flexible shaft is shown in Fig. 1.

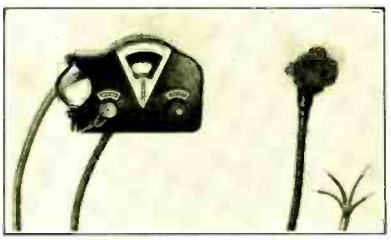

Fig. 3. Remote control for automobile receiver.

Flexible shafting which can be used satisfactorily for remote tuning are the sizes from .150 inch to .250 inch diameter. Each size and grade of shaft has a definite torsional deflection under load and standard grades of shafting have a greater torsional deflection when turned in the direction of unwinding of the outer layer than in the winding direction. To meet this condition, shafts have been developed which due to their special construction have practically equal torsional deflection in either direction of turning. A comparison of the different sizes and types of flexible shafts showing their deflection in degrees per ounce inch per foot of shaft, is shown in Table I.

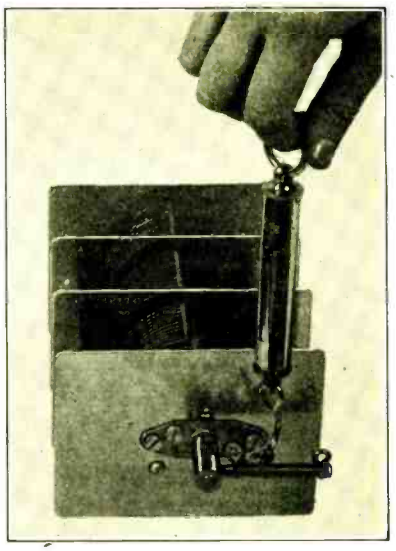

Fig. 2. Test for force required to move plates.

In designing a remote control for a particular radio receiver it is first necessary to determine the force necessary in inch-ounces required to turn the tuning condensers. This can easily be done with a small spring balance and arm attached to the condenser shaft as shown in Fig. 2. A spring balance should be calibrated in ounces and should not have a maximum scale of over 3 pounds. In place of the spring balance the arm may be notched at the top edge and a weight hanging from a hook may be moved along arm until the condenser moves. The distance from the center of the condenser shaft to the point on the arm at which the weight or spring balance is applied times the ounces required to move the condenser gives the torque in ounce-inches required to turn the condenser.

A number of trials should of course be made to be sure the maximum force is determined. This amount in ounce-inches times the degrees per ounce-inch per foot of shafting, shown in Table I, times the length of the shaft to be used gives the amount of deflection of the tuning dial if flexible shaft were direct connected. For example, if it takes 8 ounce inches to turn the condenser and we select the standard .250 inch grade H shaft the deflection in degrees of the tuning dial for each foot of shaft used would be 8 x .41 or 3.28 degrees.

If a three-foot shaft were used the dial deflection would be 9.84 degrees from the extreme point in one direction to the extreme point in the other direction. Obviously this deflection would prevent satisfactory tuning and in order to overcome this a special design is needed. The flexible shaft can not, however, be used on a direct drive to the condenser due to its torsional deflection under load. However, by the

TABLE NO. 1

TORSIONAL DEFLECTION IN WINDING AND UNWINDING DIRECTIONS IN DEGREES PER OUNCE INCH PER FOOT SHAFT—LENGTHS IN STRAIGHT POSITION.

Type shaft	D^1 Winding direction	D^2 Unwinding direction	D^1+D^2
.150 inch, grade " H "	0.88° per ft. per oz. in.	2.14° per ft. per oz. in.	3.02°
.150 inch, grade " S "	1.18° per ft. per oz. in.	2.95° per ft. per oz. in.	4.13°
.188 inch, grade " H "	0.53° per ft. per oz. in.	1.04° per ft. per oz. in.	1.57°
.188 inch, grade " S "	0.64° per ft. per oz. in.	1.35° per ft. per oz. in.	1.99°
.250 inch, grade " H "	0.17° per ft. per oz. in.	0.41° per ft. per oz. in.	0.58°
.250 inch, grade " S "	0.18° per ft. per oz. in.	0.42° per ft. per oz. in.	0.60°
.150 inch, special	0.38° per ft. per oz. in.	0.36° per ft. per oz. in.	0.74°
.200 inch, special	0.21° per ft. per oz. in.	0.20° per ft. per oz. in.	0.41°

introduction of suitable gearing this torsional deflection can be entirely eliminated.

If in place of connecting the flexible shaft direct to the condenser shaft we mount a worm-wheel on it and attach a worm to the flexible shaft, we will have to turn the flexible shaft a number of times equal to the ratio of the worm and wheel in order to rotate the condenser through 360 degrees. In order to maintain the same amount of rotation in the tuning dial as in the condenser it is necessary under these conditions to introduce a set of gears at the tuning dial of the same ratio as in the condenser but in the reverse direction. The deflection of the flexible shaft will be equal to the original figure divided by the ratio of the gears. Still figuring on the problem; if we predetermine the amount of deflection on the tuning dial which will be satisfactory and decide the gear ratios which would be most acceptable we can determine the proper type of shaft to use.

Using the formula

$$(D_1+D_2)=\frac{R\times V\times B}{T\times L}$$

we can determine any one of the variables if certain factors are determined which will be desirable.

The variables are represented as follows:

T=Force required to rotate condenser in ounce-inch.

R=Ratio of gears between flexible shaft and tuning condenser.

D_1=Deflection of shaft in winding direction in degrees per ounce inch per foot shaft.

D_2=Deflection of shaft in unwinding direction in degrees per ounce inch per foot of shaft.

L=Length of flexible shaft in feet (longest length to be used).

V=Ratio of rotation of tuning dial to rotation of flexible shaft.

B=Backlash or maximum deflection of tuning dial.

"T" can be determined for each tuning condenser by the method previously described. As can be seen, the lower this figure is the lower will be the gear ratio or the smaller the size of shaft which will be required. Some multiple

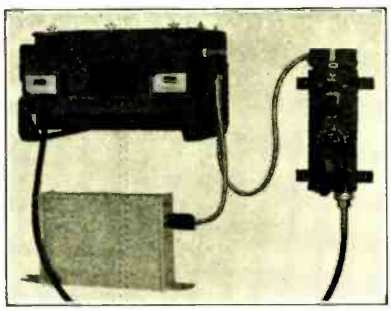

Fig. 5. Remote control equipment for airplane.

condensers with friction bearings turn exceptionally hard and for this reason do not give satisfactory results with flexible shafts unless the proper size is used.

For "R" the formula can be used to determine the proper gears to use with certain size shafts and then the most satisfactory combination selected.

D_1 and D_2 can be obtained from Table I. If a certain gear ratio is desired the formula can be used to determine the deflection of the flexible shaft which would be satisfactory.

"L" should represent the longest length of shaft which will be used with radio receiver. For example, the maximum length for an automobile receiver would probably be 6 or 8 feet, whereas the longest length that has been used in aeroplane installations is 50 feet.

In determining "V" be sure to take into consideration the use of a 180° or 360° tuning dial, as this will affect the ratio of rotation of tuning dial to rotation of flexible shaft.

"B," the backlash of the flexible shaft, is the total in degrees on dial of the deflection of the shaft from a forward to backward position. In other words, the total non-effective rotation of dial. It can be predetermined or calculated for different shafts. The sharpness of tuning of a radio receiver would determine how great a deflection might be permitted.

After calculating the gear ratio and size of flexible shaft to be used, precaution should be taken to see that the gears are carefully mounted so that there is a minimum loss from friction or improper meshing. After mounting they should be tested with spring balance and arm attached to shaft of worm to determine the loss. If no friction were present in gears it would take only $\frac{T}{R}$ ounce inches to rotate gears and condenser. There will, however, be considerable loss in the gears, but it should not be over 25 per cent and can be cut down to 10 per cent with proper mounting. If it is desired to allow for this 25 per cent loss by incorporating in original formula, it would be as follows:

$$(D^1\times D^2)=\frac{R\times V\times B}{T\times L\times 1.25}$$

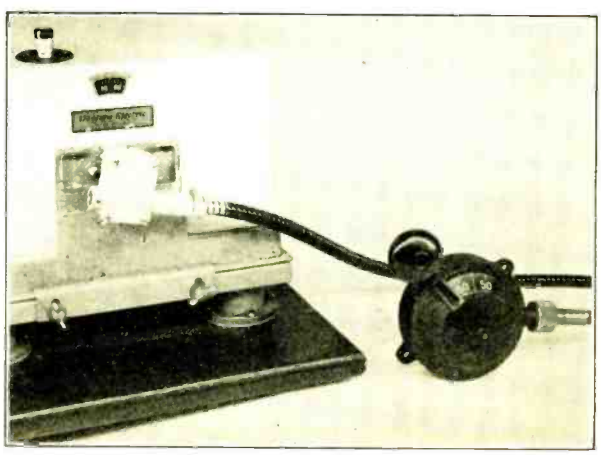

Fig. 4. Typical remote control for airplane radio.

This formula will allow for increased load of 25 per cent from friction in gears.

In order to clearly show how this formula may be used, it might be well to take as a specific problem the Hammarlund condenser type MTS shown in Fig. 2. This condenser took a maximum of 14 ounce inches to rotate same at the stiffest point. By loosening the friction bearing adjustment screws the force necessary to rotate same was cut down to a maximum of 8 ounce inches. Therefore, if T=8, we may decide to use a 16 to 1 worm and wheel on the tuning condenser and a 4 to 1 vernier dial for the tuning dial. A variation (B) of .25 degrees should be satisfactory and we will assume that 6 feet will be the longest shaft to be used. Substituting the figures decided on, we can work out by formula the torsional deflection of a shaft which will be satisfactory.

$$(D^1+D^2)=\frac{16\times4\times.25\times1.25}{8\times6}=0.41^\circ$$

Looking over our table of shafts we note that the only shaft with a total deflection of .41 degrees in winding and unwinding direction is the .200 inch diameter special shaft. We have allowed 25 per cent for friction in gears so that this shaft with a .445 inch metallic casing would give satisfactory results.

It can easily be seen that a smaller or different type shaft could be used if either "R," "V" or "B" were increased. In order to use the .150 inch special shaft we could increase "R" to 24 and "V" to 6. This combination of gears would require a shaft whose (D^1+D^2) =.94°. Inasmuch as D^1+D^2 of the .150 inch shaft equals .74° we would have very satisfactory results with this combination.

It does not seem necessary at this time to recommend ways and means for mounting the gears as the illustrations of standard sets give a general idea as to how this may be worked out. Any gear manufacturer should be able to furnish stock gears and be of assistance in suggesting means of mounting same.

For the gears at the condenser end any type may be used, but the worm and wheel seem to give most satisfactory results and are the most compact for high ratios. A typical remote control for an automobile radio is illustrated in Fig. 3 showing mounting of gears, etc.

As examples of aircraft radios with flexible shafting remote tuning control, there is the Western Electric receiver shown in Fig. 4. Flexible shafts as long as 50 feet have been used on these receivers and have given perfect satisfaction. A standard .150 inch Grade "H" shaft is used with .445 inch interlocked metallic casing. Special end fittings connect the shaft and casing to worm and tuning dial. The total gear ratio at the tuner end is 264 to one; the worm and wheel of 44 to 1 ratio is attached to a vernier dial of 6 to 1 ratio.

On the R.C.A. receiver shown in Fig. 5, a .200 inch special shaft is used in length up to 35 feet, together with a special fabric casing .445 inch diameter. On this receiver gears of ratio 40 to 1 are used, giving the accurate tuning required for aircraft receivers.

There are three types of casing which can be used and which are made in various standard sizes for use with standard sizes of flexible shafts. These are: Fabric, interlocked metallic, and two-wire metallic. The first two types are generally used for aircraft receivers due to their lighter weight, whereas the two-wire type is used for automobile radios and such, due to extreme strength and its lower cost.

There are many standard types of end fittings for both shaft and casing which may be used, or special fittings may be made to suit the individual design. Additional help in the design of flexible shaft drive for remote tuners can be obtained from manufacturers of flexible shafts who have made a study of its possibilities.

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SHORT-WAVE RECEIVER DESIGN

(*Concluded from page 27*)

Discussion of Curves

To study these curves in their proper relation they are shown together, although somewhat crowded. At low settings of the tuning condenser, a change in grid-condenser capacity has a rather large effect on the resonant frequency. At higher settings of either the grid condenser or the tuning condenser, the effect becomes less. As far as the effect of the throttle on tuning is concerned, a decrease in the grid condenser size will help, but it is better to increase the minimum capacity of the tuned circuit. This should not be carried to extremes as high ratios of inductance-to-capacity are otherwise to be preferred. When a condenser is connected in parallel with its "vernier," the latter has less effect on the tuning at high total capacity values than at low, so the tuning range will depend upon the L/C ratio. The range of a given "vernier" can be varied. If it is desired to have it cover a large frequency range a coil of such size should be used so that small capacity only is necessary to tune to the given frequency. If more of a vernier effect is desired, a smaller inductance value should be used, requiring a higher capacity value and thus giving the smaller condenser less range. When using a high L/C ratio, small capacity changes have relatively large effects and hand-capacity effects become serious—if shielding is not used.

The approximate equivalent diagram of Fig. 1 shows that the entire external "tuning" arrangement is coupled to the secondary tuned circuit through the grid condenser, so that one would expect the value of capacity in the grid condenser to have indirectly a relatively large effect on the detuning of the secondary circuit. The complete circuit diagram tested is shown in Fig. 3.

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SOME LESSONS LEARNED FROM THE PAST SEASON

By Ray H. Manson

Vice-president and chief engineer Stromberg-Carlson Telephone Mfg. Co.

THE radio industry has made real advancement in the last twelve months of general business depression. First and most important is the marked improvement in the quality of broadcasting, both from the technical, educational and entertainment standpoints.

Practically all of the broadcasters on cleared channels who are not already using high power, have appealed to the Federal Radio Commission for increase in power to 50 kw., with the view of still bettering the quality of reception for a larger audience. Receiver manufacturers have generally improved their products as regards performance and appearance and receivers of highest quality have found a ready sale to a discriminating market. On the other hand, the so-called midget receiver of extremely low price classification has come into the picture, but it is too early to predict its future. Technically, these small receivers are necessarily very limited in audio range, due to the small size of cabinet, which gives a very limited baffling area for the loudspeaker. This results in a tone quality of the vintage of 1925, as all of the fundamental musical notes below middle "C" are omitted.

Therefore, the future success of the broadcast radio receiver business appears to be in the marketing of equipment which will allow the full value of the broadcast entertainment to be realized.

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REMOTE CONTROL

IN the February issue of RADIO ENGINEERING will appear a further engineering study of the subject of modern remote control systems in broadcast, automobile and airplane radio receivers.

Electrolytic Condensers—Characteristics and Methods of Measurement

By W. L. DUNN*

An Engineering Presentation of the True Action and Performance of Electrolytic Condensers Used in Radio Receivers.

THE usual electrolytic condenser consists of a cathode and anode, an electrolyte, and a thin film deposited on the anode. The cathode serves solely as a means for making an electrical connection with the electrolyte. The electrolyte serves as one plate of the condenser, the anode as the other, and the film deposited on the anode as the dielectric.

Certain metals, notably aluminum and tantalum, when used in particular electrolytes evidence the property of film formation. The resistance of the film is a function of the impressed voltage. This resistance characteristic gives the film the properties of conducting current more freely in one direction than the other, of breaking down when voltages above a certain critical value are applied, and as a result of the thinness of the film, of acting as a large capacity when voltages below the breakdown potential are applied with the proper polarity.

The film is formed by immersing the anode in the correct electrolyte and passing a current through the solution. As the film forms the resistance of the circuit rapidly increases, the voltage is gradually built up to the maximum desired and allowed to remain at this value until the current through the condenser drops to a pre-determined value. This final voltage is known as the forming voltage. One process requires approximately 18 hours and has various ramifications which are beyond the scope of this article.

It is pertinent to note that the thickness of the film, and therefore the capacity, is a function of the forming voltage.

Although the electrolytic condenser is by no means a new development, the principles having been understood for approximately 75 years, until the last few years attempts to manufacture usable high voltage electrolytic condensers have largely met with failure because of the lack of availability of pure materials.

Commercial present-day high voltage electrolytic condensers are of two classes, wet and dry. Both types utilize aluminum anodes and either copper or aluminum cathodes. The electrolyte in the wet condenser generally consists of a solution of borax and boric acid in water. The dry electrolytic condenser uses various aqueous solutions held in a paste or binder, or made up as a colloidal solution. The operation of the two types of condensers is identical, the analogy between them being very closely that of the wet battery to the dry battery.

The life of an electrolytic condenser is a function of the amount of water and the leakage current. It is well known that in any electrolytic cell the passage of current liberates hydrogen at the anode and oxygen at the cathode, which hydrogen and oxygen comes necessarily from the electrolyte. The length of time that an electrolytic condenser, either dry or wet, will operate without decrease in capacity, increase in leakage current and increase in power factor (assuming that the unit is chemically pure and properly constructed) is dependent solely on the amount of electrolyte present in the condenser. Thus, the life of the condenser depends on the amount of current passing through and the amount of electrolyte present. According to Faraday's Law, the passage of one ampere through an electrolytic cell for 96,500 seconds is sufficient to convert 9 grams of water into hydrogen and oxygen. According to the vapor pressure of water at 120° F., the 9 grams of hydrogen and oxygen gas is capable of removing as moisture an additional 3 grams. This makes a total loss of 12 grams of water for a passage of one ampere for 96,500 seconds.

This gives to electrolytic condensers the important advantage over paper condensers of being able to calculate the life to a reasonably close approximation. In the case of wet electrolytes of reliable manufacture such a volume of liquid is used that the life of the condenser will not be less than six years, which is adequate for most purposes.

The resistance of an electrolytic condenser is a function of the shape of the anode, conductivity of the solution, the length of the current path through the electrolyte, and dielectric losses in the film. The capacity is a function of the area of the anode, the forming voltage, and the nature of the anode and elec-

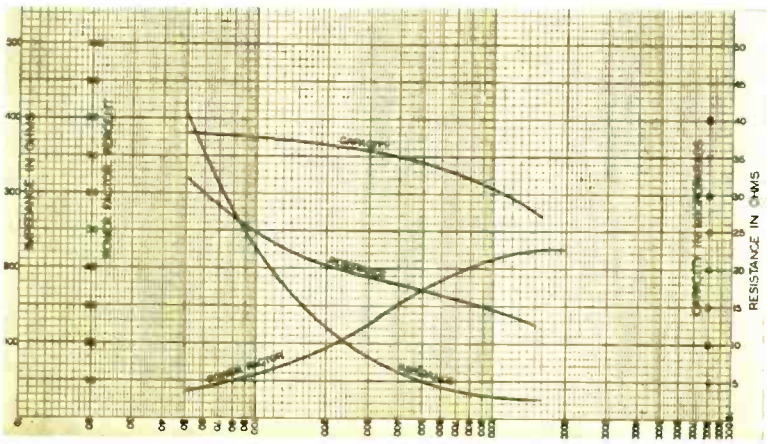

Fig. 1. Variation of capacity, impedance, resistance and power-factor.

*Engineer, Sprague Specialties Company.

trolyte. It is to be noted that the above statement refers to electrostatic capacity and resistance only.

Both the capacity and the resistance are inverse functions of the frequency of the applied e.m.f. The variation of capacity with frequency is a function of the shape of the anode. This variation of capacity with frequency is due to the lack of symmetry in the current path from each portion of the anode to the cathode. If this current path is symmetrical or of a resistance low in comparison to the reactance the capacity will be essentially constant. This variation of capacity with frequency can be minimized in any case by the use of a solution of comparatively high conductivity, and proper mechanical design.

In Fig. 1 is shown the variation of capacity, impedance, power factor, and resistance with frequency for a well-known type of electrolytic condenser used in many receivers.

Method Used to Measure Capacity

In Fig. 2 is shown a schematic drawing giving the method of measurement of these functions. It is to be noted that the method of measurement differs not at all from that used in measuring ordinary capacities with the exception that the bridge is so arranged that a polarizing voltage is applied across the condenser. This polarizing voltage is essential and necessary in making measurements of electrolytic condensers.

In Fig. 3 are shown the resistance, capacity, power factor, and impedance of an electrolytic condenser of slightly different mechanical design to the condenser whose characteristics are shown in Fig. 1. This figure shows the extent to which it is possible to go in securing an electrolytic condenser having a low power factor and small variation of capacity with frequency.

Power Factor and Capacity

There seems to be some misunderstanding surrounding the correllation between power factor and effective filtering capacity. As a matter of fact, the criterion of filtering ability of a condenser is quite different from the power factor. We can easily derive an expression which will give the percentage filtering of a condenser of resistance R_2 as compared to a condenser of equal capacity but having o resistance, that is, an ideal condenser. In Fig. 4 is shown a generalized schematic of a typical filter section. The attenuation secured on the filter is, of course, the ratio of the input to output voltages.

$$\alpha_2 = \frac{E_1}{E_2} = \frac{Z_1 + Z_2}{Z_2}$$

where E_1 = input voltage
E_2 = output voltage
Z_1 = impedance of series element
Z_2 = impedance of shunt element
X_2 = reactance of shunt element
R_2 = resistance of shunt element
α_2 = attenuation secured with capacity having resistance R_2

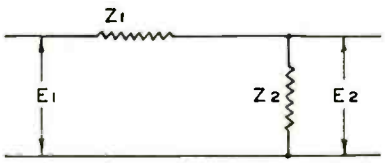

FIG. 4
Schematic of a typical filter section.

As the series element Z_1 is of necessity large in comparison to the shunt element Z_2, we can write

$$\alpha_2 = \frac{Z_1}{Z_2}$$

Now

$$Z_2 = (X_2^2 + R_2^2)^{\frac{1}{2}}$$

Or

$$\alpha_2 = \frac{Z^1}{(X_2^2 + R_2^2)^{\frac{1}{2}}}$$

Let us now consider the case of the ratio of attenuation secured with an ideal condenser having O power factor and one having a resistance R_2. The ratio for the filtering of the two cases will be hereafter designated as the filter factor in so far as it represents the percentage filtering secured with any condenser as compared to that secured with an ideal condenser of the same capacity.

$$FF = \frac{\alpha_2}{\alpha_1} = \frac{\frac{Z_1}{Z_2}}{\frac{Z_1}{X_2}} = \frac{X_2}{Z_2}$$

Where FF = the filter factor
α_1 = attenuation secured with ideal condenser
α_2 = attenuation secured with capacitor having resistance R_2
X_2 = reactance of either condenser
Z_1 = impedance of series element
Z_2 = impedance of shunt element

We may thus consider the filter factor of a capacitor as being the ratio of its reactance to its impedance. The filter factor may be shown to be

$$FF = (I - \overline{PF^2})^{\frac{1}{2}}$$

where PF = power factor

$$FF = \frac{X_2}{Z_2}$$

and

$$PF = \frac{R_2}{Z_2}$$

also

$$\overline{PF^2} = \frac{R_2^2}{Z_2^2}$$

and

$$1 - \overline{PF^2} = 1 - \frac{R_2^2}{Z_2^2} = \frac{Z_2^2 - R_2^2}{Z_2^2} = \frac{X_2^2}{Z_2^2} = \overline{FF^2}$$

$$FF = (1 - \overline{PF^2})^{\frac{1}{2}}$$

TABLE I

Power Factor	*Filter Factor*
5%	99.9
10%	99.5
15%	98.9
20%	98.
25%	96.8
30%	95.5
35%	93.5
40%	91.7
50%	86.7
60%	80.
70%	71.5
80%	60.
90%	43.6
100%	0

In Table I the correlation between power factor and filter factor is given. It is interesting to note that the reduction of filtering for a condenser having a power factor of as high as 30 per cent is only 4.5 per cent. It will be of interest at this point to calculate the effective filtering capacity of a condenser used in the filter of the power supply of a radio receiver in the case of full wave rectification where the condenser is operating at 120 cycles. We will assume that the measured capacity of the electrolytic condenser at 60 cycles is 8 microfarads. Referring to Fig. 1 it will be seen that the ratio of capacity at 120 cycles to the capacity at 60 cycles is 7.4 divided by 7.6. Reference to the same figure will show that power factor at 120 cycles is 14 per cent. Table I gives the filter factor at 15 per cent power factor as 99 per cent. The effective capacity of this condenser will then be 8 mfds. times (7.4 divided by 7.6) times .99. equals 7.7 mfd. (otherwise written as $8 \times (\frac{7.4}{7.6}) \times .99 = 7.7$). This is a reduction of only 3.7 per cent of measured capacity taking into consideration power factor of the condenser and the frequency at which it is operated in the circuit.

From the above it is readily seen that any statement that an electrolytic condenser of equal capacity to a paper con-

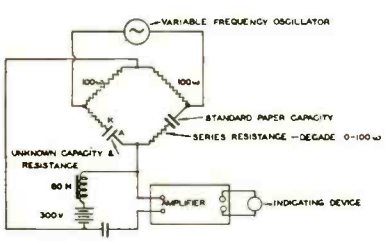

FIG. 2
Circuits of Measuring System.

denser is one-third to one-half as effective in filtering is a gross exaggeration.

The power factor of the condenser used on the input of the filter should be less than 20 per cent as there is usually 100 to 120 ma. of a-c. passing through this condenser. It is well to keep the power factor low in order to avoid possible excessive temperature rises in this unit. Condensers of the type shown in Fig. 1 fulfill this requirement quite adequately, the temperature rise in the case of either being less than 5° F.

Shelf Life

A very small portion of the film on the anode of the condenser will dissolve if the condenser is allowed to stand inoperative over long periods of time. This dissolving of the film in the electrolyte can be minimized by eliminating as far as possible all sharp edges on the anode. It is difficult to form a smooth hard film on rough edges. The dissolving of the film in the electrolyte can be further reduced by the proper choice of electrolyte and the concentrations of the salts dissolved therein. The dissolving of the film leads to high leakage when the receiver is first turned on after a long inactive period. The anode, however, is re-formed by the passage of the leakage current in an extremely short time. Even after the condensers have been allowed to stand for many months the initial leakage current will not exceed 100 ma. and by the end of 30 seconds will have dropped to some value less than 10 ma. This overload is not detrimental to the rectifier because the rectifier must withstand during normal operation the instantaneous charging current of the first condenser in the filter during each cycle. This instantaneous charging current rises to a value as high as 600 ma.

The heat produced by the passage of the leakage current through the rectifier is not detrimental to the tube in that during the period in which the excessive current is passed, the rectifier must rise from a temperature approximating room temperature to the equilibrium temperature at which it will finally operate. In so far as this action takes several minutes the initial leakage current will not cause excessive temperature rise of any of the elements within the tube, but merely accelerates its arrival at the equilibrium temperature. To date no justification has been found by any manufacturer, to my knowledge, for any statement that the life of rectifier tubes is shortened by the use of electrolytic condensers in the filter.

Noise Level of Receiver

It has also been inaccurately stated that the breakdown and reforming in the condenser leads to an increase in the background noise of the receiver. Refutation of this lies in the experiment in which a receiver having a sensitivity greater than 5 microvolts per meter and having electrolytic condensers in the filter is operated under such conditions that the electrolytic condensers are sparking vigorously. Upon substitution of paper capacitors for the electrolytics no decrease in background noise is either measured or noted.

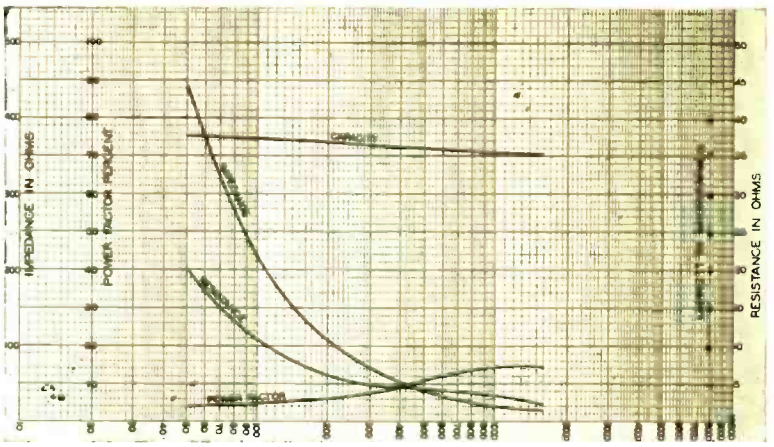

Fig. 3. Characteristics of a particular design of electrolytic condenser.

Self-Healing

The electrolytic condenser, of course, has the advantage over the paper condenser of being self-healing. The experience of most manufacturers of radio receivers during the past few years in connection with breakdown of paper condensers proves this property as an outstanding advantage.

In summation, therefore, the capacity rating of electrolytic condensers for frequencies encountered in filter circuits of the power supply of radio receivers is a true rating and has practically the same filtering effect as paper capacitors of equal measured capacity. Use of electrolytic condensers is not detrimental to the life of present day rectifiers. Electrolytic condensers are self-healing.

Finally, it is possible in most cases through use of electrolytic condensers to design a filter circuit which will have either a much lower hum level at the same cost, or a filter having the same hum level at lower cost, than when paper capacitors are used.

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GIANT AMPLIFIERS

A SERIES of interesting tests of sound amplification and transmission were made with Hoovenaire audio amplifiers from the 81st floor of the new Empire State building in New York on Christmas Eve and repeated on New Year's Eve.

Here was installed the most powerful loud-speaking equipment ever assembled and for ten hours Christmas carols were broadcast over an area of approximately nine square miles.

During the first tests, four Hoovenaire valves were attached to four 6′ Racon trumpet-type horns covering four points of the compass, with the horns beamed almost directly downward. In this position the intelligible coverage, on the street was about six city blocks except toward the west, where the understandable range was limited to only two blocks, as a wind of nearly thirty miles velocity was coming in directly from the west.

Changing the beam of the horns to a horizontal position increased the range with no apparent loss of coverage on the streets immediately around the Empire State Building. After the change of the sound beam, reports were received from as far north as 110th Street (3.7 miles from the Empire State Building); on the east from Sunnyside, L. I., nearly seven miles away, and from more than two miles away on the south. The high winds from the west prevented any great range in that direction, but apparently aided reception in an easterly direction.

Subsequent tests were made with two Hoovenaire valves attached to each horn, in an effort to increase distance, but without any noticeable difference, evidently due to one air column neutralizing the other, undoubtedly occasioned by the type of connection used. This connection of "Y" shape did not have sufficient size at the junction of the two air columns to make the additional power noticeable.

A special two-way connection, especially designed to permit the merging of two air columns without neutralizing, was used for the first time on New Year's Eve from the Empire State Building, with highly satisfactory results. Volume was more than doubled and more than 50 per cent distance gained.

Do Radio Manufacturers Care?

By AUSTIN C. LESCARBOURA
Mem. I.R.E. Mem. A.I.E.E.

WHAT'S wrong with the radio industry? Over-production? Price cutting? Production control? Lack of new market development? Lack of new devices? Failure to collect and use market data? Disregard of production and merchandising costs? In a way, yes. But in back of it all is the basic, the fundamental, psychological reason—*the radio industry does not care.*

In good times radio industrialists are in high spirits. During depression they grumble and complain generally. In prosperity they laugh at older, more conservative industries. During depression they sulk like little boys, and in a peeved state refuse to play until times are better. Associated industries have tried to help, have been more than willing to use vacuum tubes and amplifiers and loudspeakers and photo-electric cells. Music stores and automobile dealers and electric shops and a host of others have been willing to try merchandising radio sets. Apartment houses and hotels have given centralized radio and multiple antenna systems a chance. Ships and hotels and stadiums and hospitals have installed public-address systems. The phonograph companies have gone in for radio. Everybody lends a helping hand. But what's the use? Radio is so helpless!

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A Survey of a Mental Attitude Which Plays a Large Part in Making of Radio Industry What It Is Today

Unlike many other industries, devoted to products of simple design, the radio industry is dependent to a large degree on the scientific accomplishments of research laboratories. Add to that the fact that many manufacturers buy all or almost all of their components from other companies. The result: a great mass of information and products of the finest kind, available to all manufacturers who have the same ends in view. But what does the industry do about it? Nothing. No cooperation whatsoever. Either they buy at high prices the research of their competitors or independent organizations, or they try to do research of their own, at great cost. Have they ever thought of pooling their research problems and forming a research organization whose advances would be at the command of the subscribing organizations?

Market Surveys

And in the matter of merchandising, what a demand for authoritative, unbiased data, made available to all manufacturers alike! A survey of the situation shows some manufacturers taking blind guesses as to what the requirements this year will be. Guesses in the past have been wide of the mark. Will this year's be any better? And in what position is any one manufacturer to assess the entire country? And the expense when each manufacturer covers the same ground as his competitors!

What the radio industry needs is co-operation; organization; the realization that what benefits the industry benefits every member of the industry. Let us put away our petty jealousies and secretiveness; our unwillingness, for instance, to show this year's sets at this year's trade shows for fear that a competitor may learn something. No need to form new organizations and committees. The R. M. A. is excellent. But let more industrialists take full advantage of its potentialities.

Coming down to cases, just what has been done, just what should be done by way of determining the market and each manufacturer's place therein? Here is the present set-up. A liberal estimate is that the world can consume this season 5,000,000 receivers. But if all the facilities for manufacturing sets are used to their greatest efficiency, their capacity is 25,000,000 sets. Which means that if we manufacture only enough sets to sell, our production will be but 20 per cent efficient. And if we make our production more efficient by producing more, we flood our market, with consequent dumping, the effect of which we know from past experience.

Effort Is Now Individual

Now aside from assessing the entire world market for radios, each manufacturer either of parts or assembled receivers must ascertain his place in that market, must judge correctly his share of the world market. This the radio manufacturers have never done correctly. Some months ago we conducted a survey of the vacuum tube situation and found that most of the tube manufacturers intended to produce anywhere from 500,000 to 5,000,000 tubes for a total domestic tube market which these same manufacturers placed at about 75,000,000. And since there were eighty tube manufacturers doing business, it was evident that most of them were counting themselves in for too big a slice.

The same is true of all the phases of the radio industry. It is not enough to realize that the world's market this year is only 20 per cent of the facilities to supply that market. It is not enough for any one manufacturer to say, "Very well then, we will produce one-fifth of our capacity." In gauging probable sales and consequent efficient production, the proper procedure is more nearly as follows:

Let us say that last year the market consumed 4,000,000 sets. That figure will do for argument's sake, though for practical purposes accurate figures should be obtained in every case. Now of that 4,000,000 only 3,000,000 were sold to the consumer at list prices. So that will be our working basis inasmuch as the remainder is a loss, either direct or indirect; the former if the manufacturer dumped, the latter in any event since it takes a million possible customers out of the prospect category. Now Manufacturer Jones last year sold

100,000 sets, or 3 per cent of all the sets sold at list price. However, that is no guide, since Jones also dumped some of his sets. In fact, he dumped 40,000 leaving him 60,000 sets sold at list. Now the sets he sold at list equal but 2 per cent of all the sets sold at list. And 2 per cent of the estimated 5,000,000 is 100,000. Purely on the basis of last year's figures, he will make a profit on 100,000 and no more. He should produce accordingly.

Of course, Mr. Jones will say, "But this year our sets are much better than last. Our sales efforts will be greatly increased, our advertising appropriation is larger, we have some new and exclusive features." So says every manufacturer, each one nullifying the advantage of the others. And each manufacturer points to the yearly change in the sales performances of different concerns, each hoping that this will be his year. And the result of it all—utter confusion, over-production, dumping, demoralization of the entire market, and the present situation of supporting five times the production facilities required to produce the sets that we know will be sold.

Reduced Production

What is being done about this situation? A very limited survey of the production schedules shows an average of 54 per cent of last year's production being made this year. Production control is being forced on many manufacturers. Day by day orders are taking the place of commitments. Production is strictly following monthly sales, even weekly orders. Manufacturers have become wary of warehouses. Good, they have learned a lesson. On the other hand, the radio trade this year was very tardy in buying raw materials and parts. Everybody waited for something to break; just what, seems very vague. Prosperity? Orders? But anyway they waited. June business was done in September. When manufacturers finally did realize that Christmas was not waiting, they hurried up, ordered parts and wanted them delivered pronto, and are now trying to catch up. What will that mean? Perhaps putting on help—laying them off later. One large concern has not even waited for later.

And when sets are produced they must be sold. The same goes for parts. Where to sell? After assessing the regular market and deducting the malodorous dumpings we find that the industry can still make five times what it can sell. Instead of dumping the rest, or letting facilities go to rot, why not develop new markets? The very simple product, cellophane, did it. Now the cheapest cigars are wrapped in cellophane. Meats and vegetables may be seen protected by it. Just another case of opening new sales possibilities.

Possible Market Extensions

A few, a very few, manufacturers are doing the same for radio. X-ray should prove a valuable path of endeavor to the enterprising radio concern. Perhaps the greatest opportunity lies in radio for industrial purposes. In another two to five years, industrial radio may even surpass broadcasting in revenue to the parts manufacturer, while the broadcast receiver makers could easily turn to producing assembled sets to operate the many industrial devices now being developed; measuring instruments, safety devices, stop and starter machines and the like.

Which brings us to the question, how many manufacturers are doing more than wait for someone else to develop these fertile fields? There's nothing much in them yet, seems to be the attitude. Nor will there be, unless someone has ambition enough to perfect them. The firm that does the most in developing industrial radio should, if properly managed, get the most from the field. The talkies and concentration on experts also offer new outlets.

Putting aside our pride let us realize the truth, that the radio industry has common ends and so far as broadcast receivers are concerned, their products are sufficiently alike to attract the same general markets.

For which reason some organization, perhaps the R. M. A., should gather accurate merchandising material. If necessary, funds for doing so should be forthcoming from its member organizations. Radio census figures, the placement and power of broadcasting stations, the quality of their programs, these and many other factors bear heavily on the situation.

Authoritative figures should at all times be maintained. But what is more important, the members of the industry should make use of these figures. And by making use of them we mean the proper interpretation of the available market data. Such data might well be indicative of future trends, such as the present one to $49.50 sets, particularly of the midget variety. Of course, the rapid rise of radio makes each year extraordinary, and since the industry has always been in a state of flux less can be foretold from past experience than in other industries. The growth until 1929 was exceedingly fast. The decline and the business depression since then has been equally severe. In other words, normalcy is non-existent.

No Automobile Dumping

Nevertheless, it would appear that normalcy and its consequent effect of the gamblers dropping out, might be hastened by any attempt to produce and sell on other than guesses.

Although the case is not exactly analogous, it may be well for the radio industry to review briefly the formation and growth of a centralized organization in another new and rapidly growing as well as somewhat technical industry, namely, the automotive.

When the original Selden patents were finally upheld, rather than let the whole infant industry be torn apart by expensive patent litigation Seldon formed the Association of Licensed Automotive Manufacturers, which was

(*Concluded on page 42*)

PENNY WISE AND POUND FOOLISH

H. G. ERSTROM, executive vice-president of the Radio Wholesalers Association, 32 West Randolph St., Chicago, has sent out the following timely broadcast:

"You have often heard it said 'Don't be penny wise and pound foolish.' And yet it is so natural. Another tendency is to procrastinate. Do you recall the fellow who explained why he did not repair his leaky roof? He said, 'I can't mend it when it is raining and when it stops raining, the roof doesn't leak.' How many business roofs are leaking now because they were not mended while skies were clear and business was good?

"Among 'penny wise' people are some radio wholesalers. When times are good, they are too busy to find out what a good investment membership in the Radio Wholesalers Association would be. They take an indifferent attitude. When there is a business depression, then they practice a 'penny wise' policy by saying they cannot afford the price of membership.

"The Radio Wholesalers Association was organized and functions for the benefit of the entire radio industry, from manufacturer to consumer. It safeguards the best interests of the radio wholesaler and dealer. Its membership represents a majority of the purchasing power of the country from radio manufacturers.

"The annual convention of the Radio Wholesalers Association will be held in Indianapolis on February 16-17, 1931, and will be a 'down to facts and remedies' convention. Rub elbows with the fellows who will not be 'licked.'

"Join the Radio Wholesalers Association, Mr. Radio Distributor—don't be 'penny wise,' especially in these times. Don't indulge in 'false economy.' Write for information regarding membership and plan now to attend the convention in Indianapolis."

New Structure Principle in Tube Design

By WALTER L. KRAHL *

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The unitary structure of tube design is here described, showing improvement over earlier tube construction

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FOLLOWING a thorough investigation of the causes for failures in existing vacuum tubes, a new structural principle has been applied to the design of electron tubes.

Provided uniformly efficient emitters are employed and tubes are properly processed, the major characteristics: plate current emission, plate resistance, amplification constant, and mutual conductance are entirely controlled by the dimensions and relative positions of the tube's electrodes. Obviously, therefore, the structural design in vacuum tubes is extremely important. These tube parameters, which determine the sensitivity, fidelity, and power output of radio receiving sets, are appreciably affected by variations as small as one thousandth (0.001) inch in the dimensions of, and spacing between the plates, grids, and cathodes.

Uniformity of inter-electrode capacities, immunity to short-circuited electrodes, ability to withstand shock or continuous vibration without alteration in characteristics, and freedom from microphonism and other tube noises, which are controlled by the structural design of tubes, are additional factors of vital importance to both consumer and producer.

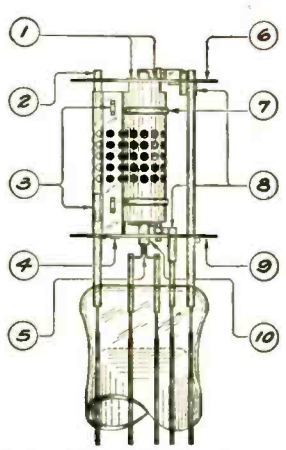
In tubes of the usual design, the electrodes are spaced at the top by the adjustment of bead wires or by insulators, and spaced at the bottom by visual adjustment of wires sealed into the stem. These stem wires are also called upon to support the entire mass of the electrodes at the disadvantage of an appreciable leverage between the rigid stem and the center of gravity of the mount.

Present Day Tubes Offer Problem in Shipping

The most painstaking adjustment of an experienced assembler of such tubes can scarcely control the exacting spacing between electrodes to one hundredth (0.010) inch, and the alignment of parts by an average operator is far less accurate.

Then, if the tubes are roughly handled, as in shipment, the support wires are distorted, those carrying the heavier electrodes being distorted more than those to which the lighter parts are secured, and the critical adjustment of the spacing between electrodes may be altered.

ARCTURUS TYPE 127 TUBE



1. Plate clamped to yoke
2. Nickel alloy supports
3. Perforated plate, anchored by welded and riveted double fin
4. Plate clamped to bottom yoke
5. Low induction insulated heater
6. Top mica yoke
7. Plate reinforcement ribs
8. Die-made connector supports for grid and cathode
9. Bottom mica yoke
10. Quick heating cathode

A striking example of the effect of shock upon the characteristics of present day radio tubes is the common practice of many tube manufacturers, of thumping tubes with undesirable characteristics until they pass the test requirements. This procedure is termed "bumping in."

The Unitary Structure Principle

The unitary structure principle, as its name implies, constitutes assembling the electrodes of a vacuum tube as a rigid unit in which the electrodes are interdependent and can not move with relation to one another. All electrodes, in such a tube, are supported at both ends by yokes in planes perpendicular to axis of the electrodes.

These yokes are anchored by riveting, clamping, or otherwise securing them to the most rigid electrode of the tube, or to an additional part, if none of the electrodes possess the required rigidity.

The tube shown in the illustration is an example of this principle as applied in the new Arcturus Type 127 detector and amplifier.

The plate of this tube is a rigid cylinder of nickel, perforated to permit radiation of heat, and ribbed to increase its sturdiness. A mica yoke is clamped to the top and another to the bottom of this plate. The grid and cathode are secured to and automatically spaced by them in relation to each other and to the plate with the precision of the die upon which these yokes are blanked.

The yokes in this tube are supplemented by a cathode collar and grid clip, both accurate die-made parts. These reinforce the unit and serve as electrical connections between the respective electrodes and the wires through the press which are connected to the base terminals. The grid clip is so designed that it also prevents any rotation of the single control grid support in the holes through the yokes.

In assembling ordinary tubes, each electrode is separately welded to the stem wires which support it, then linked together at the top with a bead or insulator, and then aligned by adjusting the stem and bead wires.

The electrodes in a tube designed in accordance with the unitary structure principle are assembled in a jig to form a rigid unit, independent of the stem. Each part fits into this unit in exactly its proper location, and can not be inserted in any position other than the correct one. No adjustment is required, the "human element" is thereby eliminated. The unit, thus assembled, slips over the stem wires and is spot-welded to them.

It is obvious, therefore, that the characteristics of these unitary structure

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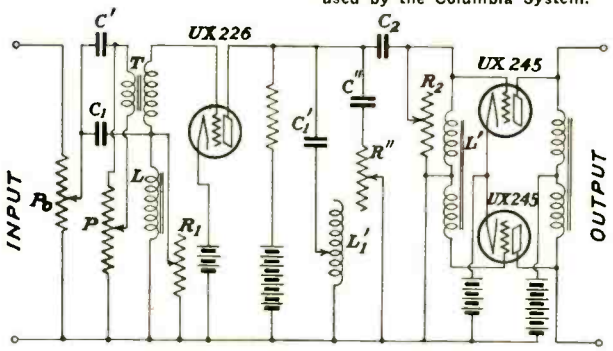
* *Chief engineer, Arcturus Radio Tube Company.*

Fig. 1. Compensated amplifier as used by the Columbia System.



Audio Compensated Amplifier

for Broadcasting and Recording Studios

By J. G. ACEVES*

ONE of the problems that confronts a radio broadcast manager is the quality of the programs as heard by the persons about to engage the services of the station. For this purpose there is usually provided an "audition room" where a loudspeaker connected to the audio system of the station reproduces the program under test before the representatives of the client and of the broadcast company. As a rule, upon the impressions—good or bad—made upon them, the transaction between them will depend. It is, therefore, of the utmost importance to satisfy the listeners then and there.

There are several reasons why a program may not come out as well as it should, even assuming good acoustics in the studio and excellent electrical equipment.

In the first place, not every man or woman talking or singing before a microphone has a good "radio voice," using this popular term for want of a more accurate one.

Then, too, it may be that the speaker or singer is not properly placed with respect to the microphone or to the pianoforte, and the proper balance of the tones is not at its best.

The imperfections of the loudspeaker and its cabinet, and the location in the audition room may not be the most advantageous. Objectionable standing waves, particularly at the lower register, may be formed in the room.

Finally, the personal equation; this imponderable factor which has to be reckoned with at all times and which may be the deciding factor in pro or in contra. The tastes of different artists, or even laymen, have to be satisfied, in some cases whether they are right or wrong when it is a question of securing the contract without sacrificing the good quality and the reputation of the broadcast station.

* *Chief Engineer; Amy, Aceves & King, Inc.*

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Herein Is Described a New Audio Amplifier System Which Permits of Compensating for Improper Room Acoustics and for Loudspeaker Deficiencies.

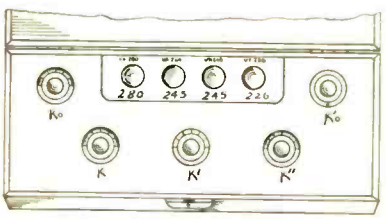


Fig. 2. Location of controls in panel.

These considerations lead to a number of applications of the ingenuity of the engineering department for the purpose of satisfying the customer as well as the management. Studios have to be treated acoustically, amplifier systems refined, loudspeakers of the best type secured, etc. All these things require a good deal of time and expense and if there were means of correcting the defects by turning a few knobs rather than by other costly expedients, whenever possible, the apparatus that could do it would be welcomed by the operating staff of a broadcasting company.

What is named the compensated amplier fulfills this mission. In the following, and by means of an example of an actual installation, the system may be better understood.

Correction of Room Acoustics

There are two methods by means of which the compensated amplifier may be used in connection with a broadcast station. First, as means of correcting the poor acoustics of the audition room, the loudspeaker defects, and, to some extent, make up for the personal tastes of the listeners. Second, to introduce it between the microphone circuit and the power amplifiers leading to the station proper with the idea of improving the acoustic balance of low and high tones with the middle register; to correct for resonant frequencies, and finally, to make the voices of certain people more pleasing and more easily understood over the radio.

A compensated amplifier, used according to the first method, was built and installed in the audition room of the Columbia Broadcasting System at 485 Madison Avenue, New York City. Fig. 1 is a schematic diagram of the circuit, and Fig. 2 shows the location of the controls in the top panel, while Fig. 3 gives the complete wiring diagram, including the a-c. apparatus and rectifier circuits.

The input to this amplifier comes at

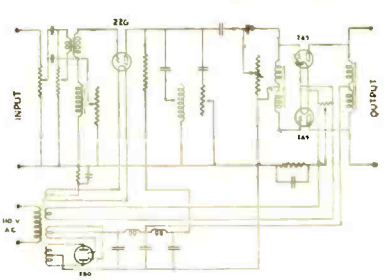


Fig. 3. Complete wiring diagram including rectifier.

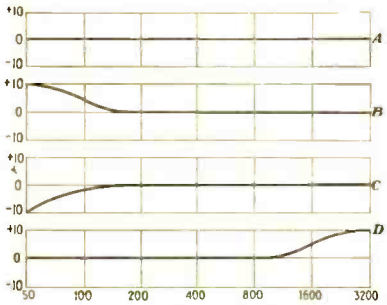


Fig. 4. Reproduction characteristics.

a rather high level. It can operate directly a loudspeaker at moderate volumes and the impedance of the source is about 5000 ohms. For this reason the total gain in the compensated amplifier should not be more than about 10 to 15 db. for the middle register in the audio frequency scale. A push-pull stage would be quite enough to secure the desired level, but compensated amplifiers with one stage only are not very successful because there would be a tendency to reinforce a very small band of bass tones and even may have tendencies to "hang over" after the impressed signal is gone. Therefore, a two-stage amplifier was built with but small gain per stage. It will be noted, by inspection of Fig. 1, that the amplifier is of the impedance coupling type even in the push-pull stage with coupling condensers of such capacities as to reinforce 50 and 65 cycles respectively thereby contributing to a general bass boosting effect below 100 cycles without a sharp peak. The amount of boosting is under the control of the shunt resistances R_1 R_2 across the impedance L and the upper half of the impedance L′ which acts as push-pull transformer of unit ratio.

Frequency Range Control

For the purpose of boosting the treble tones, a one-to-five transformer, having its primary in series with the condenser C′ and secondary in series with the impedance L, adds its voltage to the drop across the impedance L. The amount added is under the control of the potentiometer P in such manner that the primary winding receives a voltage due to the drop across the variable part of the potentiometer. The capacity of the series condenser C′ limits the lower frequency that will pass through the potentiometer which will be effectively amplified by the transformer.

On the same shaft with the movable arm of the potentiometer P, another variable resistance is mounted so that its value will diminish at the same time as the potentiometer arm will move towards a lower voltage drop across the transformer T. This resistance R″ with its condenser C″ in series, has a shunting effect upon the high frequencies impressed across the double-impedance L′. Consequently, as the knob is turned clockwise more voltage will be supplied to the transformer T and less current will be shunted from the second stage, both actions raising the high frequency level. A counter-clockwise motion will produce the opposite effect, even to the extent of subduing the high notes below normal level. The bass control knob will have a similar action upon the low frequencies, also to the extent of reducing them below the normal level by the shunting action of the resistances R_1 and R_2, both of which are controlled by the same knob. The minimum value of these resistances should not be much lower than the value of the reactance of the coupling condensers C_1 and C_2, $\frac{1}{2\pi FC_1}$ and $\frac{1}{2\pi FC_2}$ at the lowest middle register frequency (about 150 cycles) so that the general level will not go down as the bass level is reduced to the minimum.

The input potentiometer P_o acts as a general gain control for all the frequencies, and although not of the constant resistance type, it has little effect upon the tone color when the volume is raised or lowered. It has a resistance of 4000 ohms maximum. For more exacting requirements a constant resistance potentiometer or "T" type resistance control, such as is available commercially, should be preferred.

Undesirable Peaks Reduced

The functions of the compensated amplifier are not only to supply deficiencies in the frequency spectrum, but also to reduce undesirable peaks in the overall gain characteristics from input

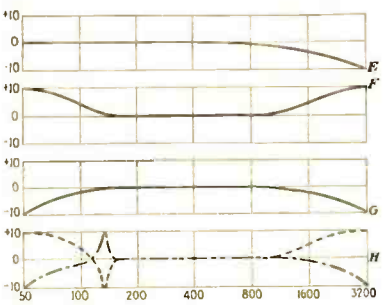


Fig. 4A. Effect of tuned shunt.

voltage to acoustic waves. Peaks due to room or cabinet resonance or loudspeaker performance should be brought low. For this purpose a tuned shunt is placed across the plate circuit of the first tube, L′1, C′2, Fig. 1, and provided with means of adjusting the period, such as variable taps in the coil L′1 is provided. The various taps are brought to a multiple switch under control knob K′, Fig. 2, while the bass control is adjusted by means of knob K and treble control by K″. The general volume control is governed by the position of knob K_o and the a-c. switch for the power supply is located at K′o. The best values of L′1 and C′1 were found by calculation and experiment, and it was decided to alter the tuning only, by means of a control knob (K′) the extent of the shunting effect being left without control knob because as a rule it will add unnecessary complications and, after all, the corrections for acoustic resonance periods, etc., need not be very accurate because they are not sharp in the majority of the instances.

Tone Control Sectional

By suitable manipulation of the controls—more specifically K and K″—the following characteristics may be given to the reproduction: (A) Normal; (B) louder bass; (C) softer bass; (D) louder treble; (E) softer treble; (F) louder bass and treble, with normal middle register; (G) softer bass and treble with normal middle register. These characteristics are shown in Fig. 4. The effect of the tuned shunt is shown in Fig. 4A, curve H, where the full line represents the overall level, the dotted line the level without any compensation. The resonance peak occurs at X, and the dot-and-dash line shows the amplifier characteristic including the effect of the tuned shunt.

Fig. 3 which gives the complete wiring diagram needs hardly any comments. It is, however, of the utmost importance that the hum levels be kept extremely low when an amplifier with bass boosting properties is built. The hum level is about the same order of magnitude as that of the loudspeaker itself when completely disconnected. This is of a very soft 120 cycle tone due to the magnetizing current in the field, the supply of which comes from a dry rectifier with an electrolytic condenser across the field coil. It becomes practically inaudible about a yard away from the speaker in a quiet room, and hardly audible by listening very closely to the speaker if the windows are open and street noise is admitted into the room.

In order to secure such a low hum level, it was indispensable to orient the audio transformer or impedances so that the fields coming from the power transformer and chokes would be at right angles. This had to be done in spite of the good shielding surrounding all of this apparatus. The "B" supply was filtered with two chokes and three condensers and the filaments were all supplied with a-c. with the middle points grounded through the bias resistors. The hum levels were observed with full bass compensating control, (Max. gain).

Planning the Radio Receiver

By J. E. SMITH*

The Elements of a Modern Radio Receiver Considered from the Standpoint of Engineering Design

JUDGING from the title of this article, the reader may be tempted to believe he is not going to get much for his money. He must not be misled, however, but must understand that the design of a complete radio receiver is an enormous problem, the satisfactory solution of which requires years of study and experience.

The start of a problem is always extremely important. It is important that the problem be begun in the proper manner, so that no step need be retraced or needless work done. And the start of the problem of designing a radio receiver is much more involved than one would be tempted to believe at first. We shall outline the start of the problem in this article. The reader must remember, however, that an adequate outline of the problem would require the writing of several articles. The material which shall be presented here in this one article will be more or less sketchy, but it will serve its purpose in furnishing the reader with an overall aspect of the problem and will serve as a forceful demonstration of the functions of the various parts of the receiver.

*President, National Radio Institute.

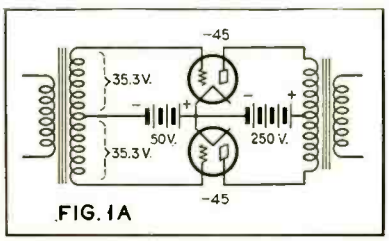


Fig. 1A. Design of output circuit.

Before starting the problem, however, it must be stated that the economic side of the problem will not be undertaken here. The manner in which this phase of the problem is to be handled depends upon commercial and manufacturing considerations which vary from time to time, from place to place and from manufacturer to manufacturer. We shall be content in this article to consider only the engineering side of the problem.

The reason for the existence of a radio receiver is its ability to furnish sounds, musical or vocal, to which its owner may listen. It is natural, therefore, that the design of the set be begun at the loudspeaker or reproducer end of the set, rather than at the antenna end.

The next consideration is the quantity of power which it is required that the reproducer furnish, and how much power it is required to put into the reproducer in order that it may furnish the required output power. In other words, a knowledge is required of how much acoustical (sound) power must emanate from the loudspeaker, and what is its efficiency. The loudspeaker engineer must furnish this information to the set designer, or at least he must tell him how much power the radio receiver will be called upon to furnish to the loudspeaker.

The Loudspeaker

The design of the speaker must be undertaken with a knowledge of what power tubes are available. There is no use in building a speaker that requires ten watts to operate if ten watt tubes are not available, or the expense of operating sufficient tubes to furnish ten watts is too great. We will not go into the design of loudspeakers, but will start the set-design problem from this point, assuming that the loudspeaker has been built, or is available, and that there is no difficulty in picking out the proper power tube, or tubes, to operate this speaker.

There are three power tubes on the market which are quite popular at the present time. These are the 250, 245 and 171A. The choice of which tubes to use depends upon the power required and the voltages supplied by the power pack, as well as the signal voltage to be applied to the grid. For example, suppose the loudspeaker required three watts of power. This power could be supplied by two 245 tubes in push-pull; each tube can supply 1.6 watt, and the two in push-pull will supply somewhat more than 2 x 1.6 or 3.2 watts. Therefore, we can use two 245's in push-pull, with 250 volts on the plate and -50 volts on the grid.

However, referring to Fig. 1A, it will be seen that in order to make these tubes work at full capacity, the peak value of

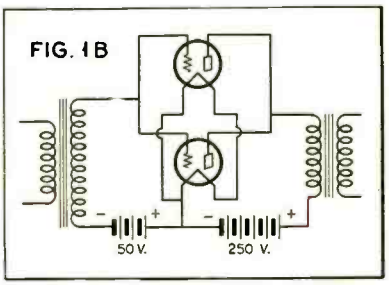


Fig. 1B. Output tubes in parallel.

the alternating signal voltage must be 50 volts. This means an effective value of 0.707 x 50 or 35.3 r.m.s. (or effective) alternating signal volts on the grid of each tube. Consequently, we must have delivered from each half of the transformer secondary 35.3 volts, or 70.6 r.m.s volts from the entire secondary.

On the other hand, two 245 tubes in parallel will supply 2 x 1.6 watts or 3.2 watts. The circuit is shown in Fig. 1B. In this case a peak voltage of 50 volts, or 35.3 volts effective will make the tubes work their full capacities. Of course, we lose the effect of the push-pull arrangement, which cancels out the even harmonics of the signal voltage, but half as much amplification is needed prior to the power stage as when the

push-pull arrangement is used. This feature may be of importance in some cases where economical audio frequency and radio frequency design is required. Considering the square law of the detector, it is seen that since half the signal voltage is required to load up the parallel arrangement, only one-fourth the amplification in the r-f. amplifier would be required than if the push-pull arrangement were used.

D-C. Operation

Another case that is of importance is that in which only a limited amount of voltage is available for the plate supply. For example, in receivers designed for operation on the d-c. mains, the voltage available is only 110 or 115 volts. Full line voltage can be applied to the plates of 171A's, with about 20 volts on the grids, six tubes being connected in the push-pull, three on a side, and the output power will not differ much from that obtained with two 245's in push-pull with 250 volts on the plates. Of course, this may seem a waste of tubes, but there is little else that can be done if three watts of power are required and only 110 volts available for the plates.

Having considered several of these side problems, let us return to the original undertaking. Let us suppose that the economics of the problems and the loudspeaker demands require that we use two 245 tubes in push-pull with 250 volts on the plate and -50 volts on the grid. Now, if our signal grid swing exceeds 50 volts peak, the tubes shall draw grid current, which will result in a certain amount of distortion. It is advisable, however, to permit some overload, so let us figure on 25 per cent overswing on the grid. This means that the peak signal voltage applied to each tube can be 50-50/4 or 62.5 volts, or an effective (r.m.s.) value of 0.707 x 62.5 or 44.2 volts per tube. The total transformer secondary voltage would then have to be 2 x 44.2 or 88.4 volts (effective). The power delivered by the power stage to the speaker would then be about three times the rated undistorted power output of each tube, or about 3 x 1.6 or nearly five watts.

Modulation Rate

From this point on we shall first consider that the power stage is always loaded up to the limit. By doing this we shall deal with maximum signal voltages, and from these values can determine the grid biases required on the other tubes in the set to prevent overloading (flow of grid current caused by the grids becoming positive). Later on we shall revise the calculations in order to determine the sensitivity of the receiver, based on a power output of 50 milliwatts and 30 per cent modulation, which has come to be accepted as the basis on which radio receivers are rated in regard to sensitivity.

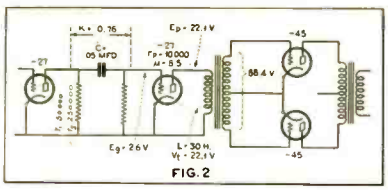


FIG. 2

Fig. 2. Amplifier circuits.

Suppose the audio amplifier consists of two stages, following the detector, as shown in Fig. 2, and that a 227 tube is used as first a-f. amplifier. Also suppose that for economic or other reasons the first a-f. tube is coupled to the detector by a resistance-capacity coupling. Also assume that the input push-pull transformer has a turn-ratio of 4 to 1.

In order to deliver 88.4 volts to the push-pull stage, the transformer must have impressed across its primary a voltage of 88.4 divided by the turns ratio, or $88.4/4 = 22.1$ alternating voltage (effective). Now assume that the transformer has a primary inductance of 30 henrys, and that the plate resistance of the tube is 10,000 ohms. We have then a condition which may be represented by the circuit of Fig. 3, in which E_p is the signal voltage developed at the plate of the 227 tube by the signal applied to its grid, the 10,000 ohms is the r_p of the tube, and the 30 h is the inductance of the transformer. Across the terminals of the transformer there is a voltage of 22.1 volts (alternating), and it is required to find the voltage E_p developed at the plate of the tube. This can be calculated by the ordinary laws of alternating-current circuits; the formula is

$$E_p = V_T \sqrt{1 + \frac{(r_p)^2}{(6.28\, f\, L)}}$$

In this formula V_T is the voltage across the transformer primary, f is the audio (or modulation) frequency, L is the transformer primary inductance and r_p the plate resistance of the tube. If we assume f equal to 400 cycles, which is the standard frequency used in testing receivers, L equal to 30 henrys, r_p equal to 10,000 ohms, and V_T equal to 22.1, we calculate that E_p must be about 1 per cent greater than V_T. This difference is small enough to neglect so we may simply say that the voltage developed at the plate of the first a-f. tube is equal to the voltage impressed on the transformer primary.

Now, the mu of the tube is 8.5. Consequently the signal voltage which must be applied to the grid of the tube in order that the plate supply a voltage of 22.1 is 22.1/8.5 or 2.6 volts (alternating, effective).

Having decided that we require an effective signal voltage of 2.6 volts on the grid of the first a-f. amplifier tube, in order to load up the power tubes, we can easily determine what bias is required on this tube. The peak voltage will be 1.414 x 2.6 or 3.68 volts. In order that the grid may at no time be positive, it is necessary that the bias be greater than this value. One of the rated voltage combinations of the 227 used as an amplifier specifies 90 volts on the plate with a bias of -6 volts. This will be very suitable for the purpose and will guarantee that the power tubes must overload considerably before the first audio takes grid current, assuring us that we are getting out of the power tubes all that they can supply.

Coupling

Next we come to the resistance-capacity coupling. But first we must make a choice of detectors, and decide what tube we shall use for the purpose and how we shall use it. We must have this information first, in order that we may know the r_p of the detector tube.

The c-bias detector is quite inefficient compared with the grid leak-grid condenser type of detector, but it has certain other advantages which make it more desirable. In the first place, its overload limit is higher, that is, it can handle greater r-f. signal voltages before it overloads than can the other type of detector. Moreover, it does not attenuate the high audio frequencies as does the other. Again, due to the presence of the grid leak and grid condenser across the tuning circuit preceding the detector, tuned circuit alignment is more difficult when using this type of detector than when using the c-bias detector. And finally, due to the resistance reflected into the r-f. tuning circuits by the grid condenser and grid leak, the r-f. amplification is considerably reduced, so that what we gain in efficiency of rectification may be lost in r-f. amplification. It is often doubtful therefore, if any increase of sensitivity is gained by using the grid leak-grid condenser type of detector.

Therefore, we decide upon the c-bias type of detector. We must decide upon what voltages to use on it. At low signal voltages the c-bias detector is rather inefficient. Experiment has shown that if a signal voltage of one volt is applied, and if the carrier modulation is in the neighborhood of 30 per cent, it will deliver in its plate circuit an audio voltage of about one volt. In other words, for voltages of this order of magnitude the detector may be said to have a voltage ratio of about 1 to 1. For larger signal voltages the step-up of 227 may become as high as four to one, but as we have seen before, we only require 2.6 volts at the input of the first a-f. tube in order to completely load up the power stage, so that if there is not much loss in the coupling resistance, the whole system is likely to be severely overloaded.

However, detector overloading is much more objectionable than even severe audio amplifier overloading, on account of the double humps and the apparent broadness of tuning that occur. Therefore, it is well to make the overload point of the detector quite high, say about -12 volts bias. This will cause very severe audio overloading before detector overloading can occur.

From the characteristic curves of the 227 best rectification is obtained for a bias of -12 volts when the plate voltage is about 120 volts, and the corresponding r_p is about 22,000 ohms.

Having decided all these things we can tackle the resistance-capacity coupling. Fig. 4 shows the equivalent circuit. It consists of a voltage E_p, which is the audio voltage delivered by the detector plate to the coupling circuit. In series with this we have the r_p of the tube, 22,000 ohms. The rest of the circuit looks unfamiliar, but it will be seen to be identical with the resistance coupling circuit in Fig. 2. It is drawn in this manner to indicate that the circuit is really a voltage divider, only part of the voltage E_p being delivered across the points ab since part of it is lost in the resistance r_p; and again, only part of the voltage across ab is delivered to the resistor r_g, since part of it is lost in the coupling condenser C.

Voltage Ratio

If the coupling condenser C is large enough, say not less than 0.05 mfd., the voltage ratio of the coupling circuit may be calculated by the formula

$$K = \sqrt{1 + \frac{r_c}{r_g} + \frac{r_c}{r_1}}$$

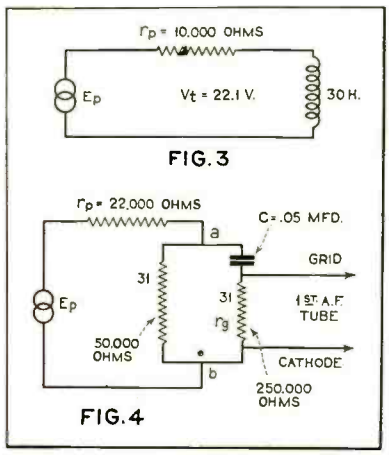
If r_p is 22,000 ohms, r_1 is 40,000 ohms, and r_g is 250,000 ohms, which are quite suitable values to use, then the voltage ratio is calculated to be equal to 0.65. In other words, we have a step-down of 0.65 in the resistance coupling circuit. This seems rather low. We can improve it by increasing either of the resistances, but we must not make them too large. If we make r_g too large motor-boating might result; as we increase r_1 we have to increase the b voltage supply which may not always be desirable, depending on the design of the power supply.

Let us increase r_1 to 100,000 ohms. Then K becomes equal to 0.76. This is a little better, but not a great deal. We might go further, but we may get into trouble, so we may let well enough alone for the present. If we find out later that we need more amplification we can make whatever changes seem desirable.

It has been shown that 2.6 volts are required at the grid of the first a-f. tube. The audio voltage which the detector plate must supply is therefore 2.6 x 0.76 = 1.97, or about 2 volts r.m.s. If the voltage ratio of the detector is 1 to 1, as mentioned before, then the modulated r-f. voltage which must be applied to the detector grid is about 2 volts r.m.s. Since the peak value of this voltage is 2 x 1.414 or 2.8, and since the detector bias is -12 volts, there is very little likelihood of overloading the detector before the audio system is badly overloaded.

Little need be said regarding overloading of the r-f. tubes before the a-f. or the detector is overloaded. Even if the r-f. stage immediately preceding the detector has as low a voltage amplification as 2 to 1, the r-f. voltage on the grid of that tube need only be 2/2 or 1 volt in order to completely load up the power stage. This is safe so far as overloading the r-f. tube is concerned, because the peak value is only 1 x 1.414=1.4, whereas the bias voltage specified for the 224 type of tube is -2 volts.

There are other reasons, however, why it is not desirable to overload the r-f. tubes, which we shall not discuss here. These are cross-modulation, damping of tuned circuit and resulting broadness of tuning, due to flow of grid current, etc. For these reasons, if adequate pre-selection is not employed, it may be well to connect an auxiliary volume control potentiometer across the antenna and ground binding posts, operated simultaneously with a potentiometer controlling the screen voltage or the r-f. grid voltage. Care should be taken in doing this in order to avoid detuning due to the potentiometer.



Figs. 3 & 4. Equivalent circuits.

To determine how much radio frequency amplification is required we may first decide upon the required sensitivity of the entire receiver. Sensitivity is defined as the number of microvolts due to the signal, which must be impressed on the antenna, in order that a power of 50 milliwatts (0.050 watt) be delivered to the loudspeaker.

Suppose we desire a sensitivity of 20 microvolts. This is about the sensitivity of some of the better sets on the market. Now we revert back to the loudspeaker again.

Push-Pull Output

The maximum undistorted output of the push-pull stage is about 4 watts, and this is obtained with a peak signal voltage of 50 volts, or an effective signal voltage of 50 x 0.707 or 35.3 volts. The power delivered to the speaker is proportional to the square of the signal voltage, so that in order to deliver 50 milliwatts (0.050 watt) to the speaker, the signal voltage required at the grid of the 245 is

$$E_g = 35.37\sqrt{\frac{.050}{4}} = 3.9 \text{ volts (r. m. s.)}$$

Now we may calculate as before:

Voltage across secondary of input push-pull transformer . . 2 x 3.9=7.8

Voltage across primary of transformer . . . . . 7.8/4=1.95

Voltage at plate of 1st a-f. tube. . =1.95

Voltage at grid of 1st a-f. tube 1.95/8.5=0.23

Voltage at plate of detector tube 0.23/0.76=0.30

Voltage at grid of detector tube 0.30/1=0.30

This is what is called the detector sensitivity; that is, it is the voltage which must be impressed at the input of the detector in order to produce a 50 milliwatt input to the speaker. The figure 0.30 volt is equal to 300,000 microvolts, so that the r-f. amplification which is required is

300,000/20 or 15,000

This figure is quite reasonable. It is not difficult to obtain an r-f. voltage amplification of this value, or even slightly higher, over the entire broadcast band, with three 224 tubes and four tuning circuits. As a matter of fact, the amplification tends to run considerably higher than this on the higher frequencies, and rarely drops below 15,000 at the low frequencies in well designed receivers.

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ARE SIDEBANDS REAL OR IMAGINARY?

IN the February and March issues of RADIO ENGINEERING, will be published further articles on the subject of radio transmission theory, prepared by engineers who have given much thought to the present wide discussion of the Stenode radiostat. These articles are authoritative and educational.

Various Factors in Modulation

By C. H. W. NASON

THE theory of modulation has not received any addition of importance since the original paper by Heising in the Proc. I.R.E. for August, 1921. We assume that a carrier oscillation is modulated as to amplitude in accordance with low frequency variations representing voice currents, television images, etc. One point which is not quite understood by the layman is the fact that a completely modulated wave where the amplitude is swung from zero to twice the normal value represents a power variation of from zero to four times the normal level, necessitating the use of amplifiers at the transmitter capable of handling the high power encountered at the modulation peaks.

Most engineers are familiar with the method of Jolliffe utilizing a v.t. peak voltmeter across a tuned circuit. The equation for computation of the percentage modulation being

$$\text{Per cent M} = \frac{(\text{I mod} - \text{I carr})}{\text{I carr}} \times 100$$

The method is accurate to 4 per cent.

The second method is available where a rapid thermoammeter is employed in measuring the antenna current.

Where I_1 is the current reading with the carrier unmodulated and I_2 is the reading when steady modulation is employed. I_0 is the *peak* value of the unmodulated oscillation ($I_0 \sin \omega t$). Then:

$$I_1 = I_0 \times 1/\sqrt{2} \text{ and}$$

$$I_2 = I_0 \times \sqrt{\frac{M^2 + 2}{4}}$$

Eliminating I_0

$$M = \sqrt{2\,(I^2_2 - I^2_1)}\,/\,I^2_1$$

In the specific case of complete modulation ($M = 1$).

$$I_2/I_1 = \sqrt{3/2} = 1.22$$

That is to say, when a continuous modulation is applied an increase of about 20 per cent in the antenna current will indicate complete (100 per cent) modulation of the carrier.

A little work on the part of the student will yield a table for various values of "M" against increase in antenna current as read from a thermal ammeter connected in the antenna circuit. If accuracy is desired it is of course essential that a meter having an open and easily read scale be employed.

▲

A Note on the Engineering of Modulation in Radio

DO RADIO MANUFACTURERS CARE?

(*Concluded from page* 35)

assigned the basic patent on the automobile. This patent was for a device to allow a motor to be placed in a carriage and to engage and disengage the motor. In other words the basic principle of the automobile was the clutch. Each of the associated manufacturers paid the A. L. A. M. five cents per horsepower for the automobiles they produced, and most of this money was used to develop original data for the industry as a whole. Many of the standards used in the automobile business today are the old A. L. A. M. standards. When Henry Ford finally broke the Selden patents the A. L. A. M. was so well entrenched and universally respected that it was continued as the Society of Automotive Engineers. That society today continues to function as a very important unit in the motor industry.

We might point out the fact that although the automotive business has become one of the most highly competitive in the world, nevertheless there is no condition such as exists in the radio industry. There is no dumping of distressed merchandise each year as is the case in the radio set business. When you buy an automobile you are reasonably certain that the price of your car will not be surreptitiously cut even before you have received delivery. You can't go down to any automotive Cortlandt Street and buy your car 50 per cent off list, as you can at the end of the year in the radio racket.

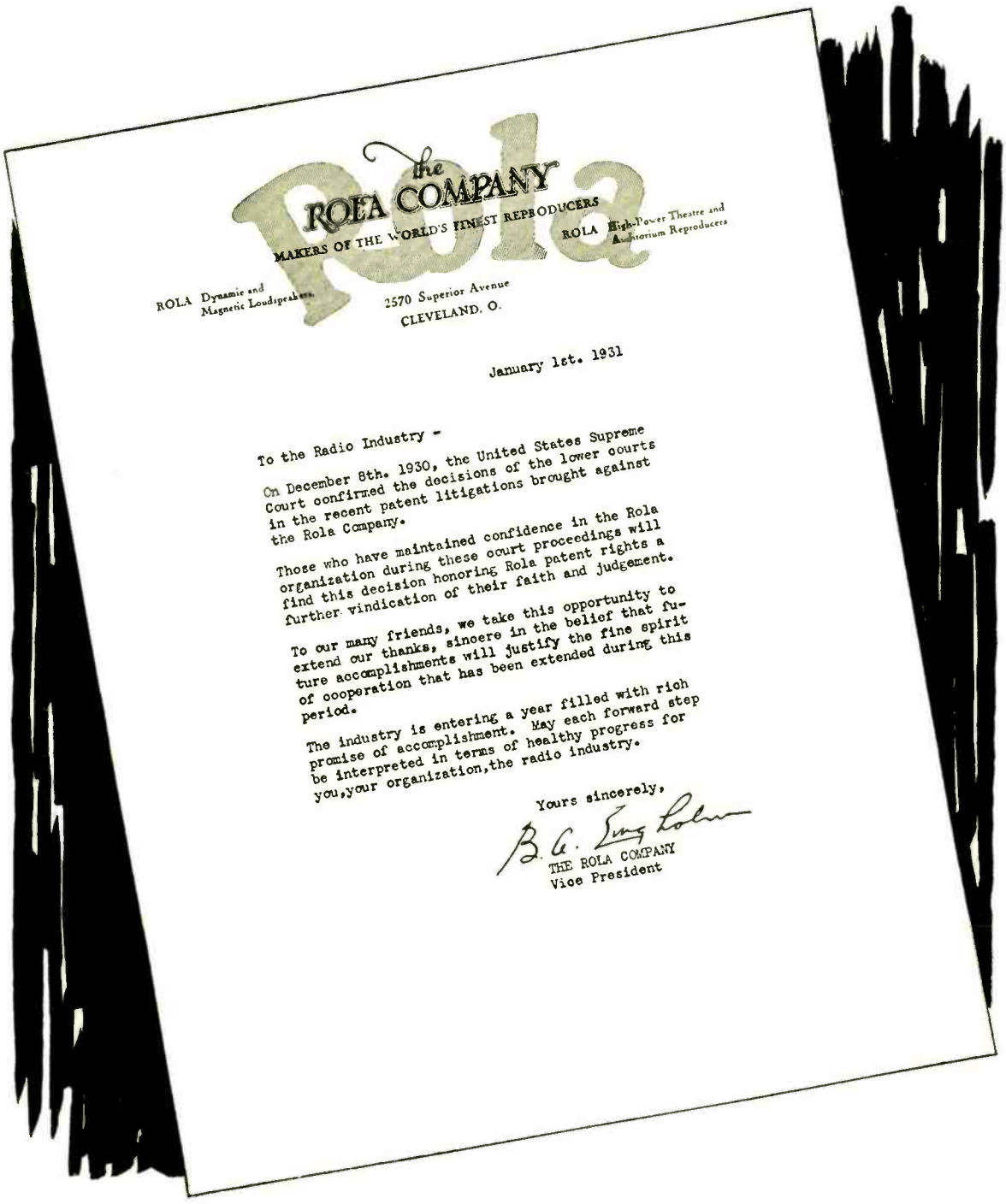
Opportunity for R.M.A.

So too might the R. M. A., were it the organization it should be, with the cooperation of the set and parts manufacturers, instead of confining itself chiefly to pulling off trade conventions which are not trade conventions, assume the double duties of central merchandising information bureau and association of radio standards; researching impartially, formulating standards, and through ostracism of any delinquent by the others, enforce these standards.

Nor would such a move strangle initiative. Individual radio concerns would continue their quest for newer and better devices, greater refinement. In fact, the inability under such a system to dupe a gullible public with differences rather than betterments, superficial qualities rather than sound engineering, would force those who would keep in the race to seek and use actual improvements.

The radio industry is in a sad state of disorganization. To rectify this condition we respectfully submit the proposal that the R. M. A. or other organization, through subscription of member companies, evolve a set of engineering standards, to be conformed to by all member companies, to gather and disseminate merchandising data of all kinds, to act as a clearing house for the trade and to maintain by disciplinary measures list prices on all radio products throughout the year.

Garbage is not dumped in the public streets of civilized communities. Radio refuse should likewise be disposed where it will not offend.



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January 1st. 1931

To the Radio Industry -

On December 8th. 1930, the United States Supreme Court confirmed the decisions of the lower courts in the recent patent litigations brought against the Rola Company.

Those who have maintained confidence in the Rola organization during these court proceedings will find this decision honoring Rola patent rights a further vindication of their faith and judgement.

To our many friends, we take this opportunity to extend our thanks, sincere in the belief that future accomplishments will justify the fine spirit of cooperation that has been extended during this period.

The industry is entering a year filled with rich promise of accomplishment. May each forward step be interpreted in terms of healthy progress for you, your organization, the radio industry.

Yours sincerely,

B. G. Ing Rolan

THE ROLA COMPANY
Vice President

WORK OF BUREAU OF STANDARDS

IN the annual report of the Secretary of Commerce, Washington, D. C., appear references to undertakings of the radio section, as follows:

Primary Frequency Standard

A primary frequency standard with an error of one part in several millions, consisting of four special piezo-oscillators of great accuracy, has been in operation for several months. Currents are furnished by this standard at 100,000, 10,000, 1,000, 100, and 10 cycles per second, and seconds impulses are given. These accurately known frequencies can be made available for measurement purposes in most of the bureau's buildings. The frequencies of the four piezo-oscillators are found to increase at the rate of about one part in a million per month.

Secondary Frequency Standards

Some of the causes of erratic behavior of temperature-controlled piezo-oscillators constructed by the bureau have been eradicated by improvements in design. Two of the best piezo-oscillators maintain their frequencies from day to day within ±1 part in a million. The frequencies of this group of piezo-oscillators have been found to increase about one or two parts in a million per month.

Standard Frequency Dissemination

Regularly scheduled transmissions of eight frequencies per month were sent out for the use of all those interested in accurate frequency calibration. The accuracy of these transmissions is better than 0.01 per cent.

Intercomparison of Frequency Standards of Various Laboratories

The frequency standards of several foreign countries were inter-compared by carrying a piezo-oscillator to the different laboratories and by measurements on a quartz light resonator circulated by Japan. The latter measurements showed the national standards of four nations to be in agreement within 0.002 per cent.

Measurement of Radio Field Intensity

Field intensity measurements made at frequencies from 550 to 5,400 kilocycles per second over distances up to 3,200 meters over fresh water show that 15 per cent of the signal is absorbed at 1,500 kilocycles and about 50 per cent is absorbed at 5,400 kilocycles. Measurements of transmissions from broadcasting and Government stations at distances up to 270 kilometers show that the absorption at a distance of 270 kilometers is 99 per cent for a 760-kilocycle transmission and 90 per cent for a 338-kilocycle transmission.

Variations of Radio Wave Intensity and Direction

Measurements with an automatic fading recorder at the Kensington field station show that magnetic storms do not affect the received intensity but increase atmospherics. The eclipse of April 28, 1930, did not affect the records.

Height of the Kennelly-Heavyside Layer

Oscillographic records made on pulse signals sent by NKF on 4,045 kilocycles and 8,650 kilocycles show the virtual height of the Kennelly-Heavyside layer to be from 225 to 250 kilometers on 4,045 kilocycles and about 290 kilometers on 8,650 kilocycles. A 100-kilometer layer was also observed on the lower frequency. The height of the layer changes during the day and is affected by magnetic storms.

Studies of Piezo-Electricity

The modes of vibration of crystalline quartz plates of various cuts have been studied by observing the patterns formed by lycopodium powder on the surfaces of the plates. The air currents emanating from the periphery of a vibrating circular plate have been utilized to determine the angle of vibration of the plate. The experimental work has been accompanied by a theoretical study of the problem of free vibrations of an elastic solid.

Radio-Frequency Power Factor of Mica

Power-factor measurements between 100 and 1,000 kilocycles per second were made on 34 samples of domestic and foreign mica for the Bureau of Mines for use in a report to the War Department.

Dr. J. H. Dellinger, past president of the Institute of Radio Engineers, is chief engineer of the Radio Section, Bureau of Standards.

VACUUM TUBE PROGRESS IN 1930

THE development and application of Thyratron tubes were actively continued and they are now available in a number of different sizes with peak current ratings from ½ to several hundred amperes and capable of controlling power up to 450 kw. per tube.

The Thyratron inverter has proved very useful in special cases for supplying alternating-current power from a 110 or 220-volt direct-current line. Special tubes were designed for this service having 110-volt cathodes to work directly from the line.

The operation of Thyratron tubes on high frequencies (up to several thousand cycles) requires rapid deionization of the mercury vapor to permit the grid to regain control during the short time that the anode voltage is negative. Extensive investigation of deionization time resulted in a design of tube particularly adapted to high-frequency use.

A new form of Magnetron tube for the generation of ultra-high frequencies has two anodes and a cathode and operates in a magnetic field. It extends the range of frequencies somewhat higher than can be obtained with the conventional form of three-electrode tube. Useful amounts of power can be obtained at frequencies up to 400,000,000 cycles. A tube was produced for an output of about 10 watts at this frequency and a larger water-cooled tube was designed which gives an output of about one kw. at 100,000,000 cycles.

Investigation of the effects of high-frequency electric fields was continued. Several hospitals were supplied with apparatus for studying the effect of these fields on the human body. Other experimental work was done on the use of high frequencies in the heating and cooking of foods and various drying or curing processes. This method of heating is particularly useful where it is desired to heat a non-conducting material uniformly throughout its entire mass.

The application of vacuum tubes in the field of electrical measurements was extended by two new tubes, one a cathode-ray oscillograph tube, the other a four-electrode tube characterized by its extremely low grid current.

The cathode-ray tube is of the high-vacuum type and operates with an anode voltage of 3000 to 5000 volts. It may be controlled by either electric or magnetic fields; and as it gives a much brighter image than former tubes of this general type, it may be used in ordinary daylight without shading. A photographic record may also be obtained. It is particularly useful in the study of transients and high frequencies.

(*Concluded on page 46*)

CARRIER-CURRENT SIGNALING

THE engineering developments in carrier-current signaling carried out in the laboratories of the General Electric Company during the year 1930, are reported as follows:

The standard line of duplex apparatus was redesigned to increase further the flexibility and reliability of the automatic control and extension features, in order to permit more general operation in conjunction with existing metallic telephone lines. Operation through PBX boards and similar office telephone facilities is now provided in a large percentage of all new installations.

The simplex telephone equipment, previously introduced, led to a demand for additional types of this nature, primarily because of the low cost and high reliability that were attained. To meet these demands two new simplex equipments were developed with improved electrical and mechanical designs resulting in increased range and greater reliability.

The new 7.5-watt equipment is of compact design and arranged for floor or table mounting. It is intended primarily for locations which do not need the superior flexibility of control and signaling incorporated in the duplex equipments. It has a communicating range of approximately 100 to 150 miles depending on the character of the transmission network. Although normally equipped with loudspeaker calling and a telephone handset intended for use directly at the transmitter-receiver equipment, provision is made to add four-wire telephone extensions, and also full selective ringing; both in the form of attachments.

Through the use of mercury-vapor rectifier tubes, the necessary power supplies are obtained directly from the alternating-current station lighting supply. A new type of gas-electric unit is now available for use at locations where the alternating-current power supply source is subject to interruptions. The overall dimensions of the new equipment are 11 by 18 by 30 inch, net weight 150 pounds.

A new quarter-watt equipment is mounted in an outdoor weatherproof cabinet for use by patrolmen, linecrews, etc., at sectionalizing points, unattended substations, and similar locations requiring only intermittent operation. Although intended for permanent installation, it is unusually compact and light in weight. The cabinet, complete with all dry-battery power supplies, transmitter-receiver circuits, and operator's handset measures only 17 by 18 by 34 inch overall, and has a net weight of only 150 pounds. It has an average communicating range of approximately 75 miles.

The outstanding features of these new equipments are: high reliability, high-power output, and operation practically as simple and automatic as that of duplex equipment. They are designed to operate with any other G-E carrier-current equipment, either simplex or duplex, which are provided with selective ringing or loudspeaker calling.

Other Carrier-current Equipment

Paralleling the advances in design and application engineering of communication apparatus, three additional uses of other carrier-current apparatus reached the commercial stage.

Outdoor transmitter and receiver equipments were developed to indicate at an attended station the position of oil circuit breakers, temperature indicators, and abnormal conditions in an unattended substation. The power input to the carrier transmitter is closed when an abnormal condition occurs, and the transmitted carrier energy is picked up by a corresponding receiver at an attended station where either conventional line drops, signal bells, or other indicating means can be employed to call the attention of the operator to the condition being recorded.

Application of the carrier equipment may be made to telephone lines (without interfering with telephone conversations), to distribution circuits, or to high-voltage transmission lines. The transmitter and receiver cabinets measure 9 by 13 by 18 inches overall, have a net weight of 50 pounds each, and are arranged for outdoor pole mounting.

Another new application employs a simplified carrier-current impulse transmitter and receiver for use with distance relays, or with other relaying schemes to meet conditions which would otherwise result in undesirable cascading or delayed operation of the proper breakers. Application can be made to telephone lines without interfering with communication, although the transmission of the carrier energy is usually affected over the power transmission line which is being relayed. The carrier equipment is similar in design to the new carrier-current telephone equipment.

A new type of vacuum-tube telemetering equipment was developed primarily for operation in connection with carrier-current transmission, although it is equally applicable to metallic telephone circuits. Through a unique arrangement of light-sensitive devices the position of a very sensitive indicating instrument can be made to actuate recording and curve-drawing meters of relatively large energy requirements. Almost perfect accuracy is obtained regardless of changes in characteristics which might take place over a period of time in the associated apparatus.

Notable advances were made in the design of coupling capacitors and other coupling apparatus used in connection with carrier-current equipment. A new line-tuning unit permits the transmission and reception of a multiplicity of carrier-current frequencies through a single set of coupling capacitors. The tuning units are arranged for outdoor mounting and have a panel layout which permits the addition of multiple-frequency tuning and trap circuits as required by the conditions of each individual installation.

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VACUUM TUBE PROGRESS IN 1930

(*Concluded from page 46*)

The low-grid-current tube is a space-charge grid type of tube designed for a minimum of grid current. This current does not exceed 10^{-15} amp. The tube is being used for the measurement of extremely small currents or high resistances, for amplification of the current from a photoelectric tube, and for replacing electrometers.

Vacuum tube technique was applied to the making of one of the oldest of light-sensitive devices — the selenium cell. In the new selenium tube the sensitive surface is formed on a glass plate which is mounted in an exhausted bulb. The selenium tube is more sensitive than the photoelectric tube for certain classes of "off-on" operation and is particularly suitable for actuating the grid of a Thyratron tube to control a large amount of power by means of a light source.

Liston, General Electric Review.

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NEW STRUCTURE PRINCIPLE IN TUBE DESIGN

(*Concluded from page 36*)

tubes are more uniform than those of ordinary tubes, and that they are virtually "matched" tubes. And, since one electrode can not move with relation to another, these characteristics will not be altered by jarring in shipment, or subsequent submission to vibration or shock. Then, since the electrodes can not move the few thousandths of an inch which could alter the characteristics of the tube, it is certain that they can not move such greater distances that would permit short-circuits between any two electrodes. Microphonism and other tube noises are the result of relative motion between the parts of tubes, so they too, are eliminated in these unit structure tubes.

PHILCO FORGES AHEAD

Confident that 1931 is going to show an improvement over 1930 for the sale of home radios and that in addition a great and virtually new market will be opened through the perfection of the automobile radio, the Philadelphia Storage Battery Company, makers of Philco radios and Philco-Transitone automobile radios, is expanding its factory and laboratory facilities through the erection of a new five-story building adjacent to its present plant in Philadelphia. The company has also acquired the Holmes Mills a few blocks distant from Philco headquarters at C and Ontario Streets.

This is the concrete support given by Philco to a prediction that business for the whole radio industry is going to be better in 1931. So far as Philco itself is concerned, the year 1930 was a banner one with sales going 100 per cent ahead of the preceding year.

"Sales of new radios for 1930 proved surprisingly good," James M. Skinner, vice-president and general manager of Philco said in announcing plans for 1931.

"Most predictions placed the probable market for the whole industry at between 50 and 60 per cent of the 1929 market. But the latest figures available indicate that the 1930 sales were nearer 70 per cent of 1929, which is surprisingly good.

"It looks now as though sales in 1931 would be, at least, a little better than those for the year 1930, for home sets, with an enormous additional market of 21,000,000 automobiles for automobile radios."

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PAPER TUBES

Announcement is made by the Paper Tube Co. 1718 North Damen Ave., Chicago, Ill., of the installation of new machinery, and the acquisition of sufficient additional floor space, to more than double the present production of the line of paper tubes manufactured by this company.

The Paper Tube Co. has, for many years, supplied the radio and allied industries with tubes for coil windings, and the above announcement is eloquent proof that they meet with the unqualified approval of manufacturers.

Samples of tubes will be sent to readers of RADIO ENGINEERING upon request.

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A STEPPING STONE TO WORLD TRADE

For more than 100 years American business men have regularly attended the international fair at Leipzig to extend their interests in world markets. Today the historic Fair attracts visitors from 72 countries in all parts of the world, while American participation has increased in the interval more than a hundredfold. The success of the great world exchange throughout the seven centuries of its existence, is due to its importance as a stepping stone to world markets. The Liepzig Trade Fair will be held this year from March 1–7.

The Spring Fair will comprise 10,000 exhibits, assembled from 22 countries, thus constituting the largest and most varied market in the world. The exhibits of similar merchandise will be displayed in the same or closely grouped buildings. There are some 67 buildings in all, including the largest exhibition halls ever erected. The visiting buyers at Leipzig find it possible to shop through a score of countries quickly and economically. An American exhibitor last year found that with an expenditure of six days time and $2,000 he accomplished more than by a four months trip through Europe and an outlay of ten times the amount spent to exhibit.

An attendance of some 200,000 buyers is assured at the Spring Fair, including 30,000 from foreign countries. The United States will send more than 100 characteristic exhibits and upwards of 2,000 buyers from all parts of the country. A special American headquarters will be established and every facility offered for transacting business.

The wealth of opportunities offered at the Leipzig Fair may be judged from the number of exhibitors in the leading divisions. The Fair will include 823 exhibits of toys, of rugs and textiles, 795, office appliances, 882, applied arts, 438, household goods and appliances, 895, notions and fancy goods, 633, clocks and jewelry, 220, and 604 displays of glass and ceramics. Full information concerning every detail of the Fair may be obtained by addressing the Leipzig Trade Fair, Inc., 11 West 42nd Street, New York City.

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WIRE CLOTH

On and after January 1, 1931, the corporate existence of The New Jersey Wire Cloth Company will cease and the business continued by the John A. Roebling's Sons Company of which The New Jersey Wire Cloth Company is a subsidiary.

The sale and distribution of wire cloth and wire netting, will be continued through the parent company at Trenton and through the Roebling branches.

The Roebling Company will assume all the contracts and obligations of The New Jersey Wire Cloth Company, while the same personnel will continue the manufacture and sale of the entire line.

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NATIONAL UNION SIGNS TWO MANUFACTURERS

Henry A. Hutchins, general sales manager of National Union Radio Corporation of New York upon reviewing November activities of that company, when he returned from a mid-western trip in December, announced that National Union Radio tubes have been taken on as standard equipment by two more manufacturers; Gray & Danielson, San Francisco, Calif., and Art Woodwork Company, Seattle, Wash.

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MARKED PROGRESS IN GOVERNMENT'S RADIO MONITORING SERVICE

The efforts of the federal government to provide better reception of broadcast programs and other radio transmissions are revealed in the annual report of W. D. Terrell, Chief of the Commerce Department's Radio Division, made public recently.

One of the chief causes for poor reception, the report points out, is the tendency of radio transmitting stations to deviate from their assigned wavelength or frequency. In order that a close check may be kept on all stations and that those deviating may be immediately advised, a widespread system of monitoring has been inaugurated by the Radio Division. This monitoring service consists of a primary station located at Grand Island, Nebraska, and nine secondary stations in various parts of the country. In addition to these stations the division maintains a fleet of six test cars for supplementary work. The site of the primary station was chosen as near the geographical center of the country as possible, it is pointed out. The location is practically free from all man-made electrical disturbances.

The apparatus installed in the various monitoring stations is the most complete of any in the world. During the last fiscal year tests conducted at the primary station at Grand Island resulted in reception of transmissions from numerous foreign countries, including those as far separated as Russia and Argentina. A recent program transmitted from Tokyo was picked up at this primary station and made available for broadcasting in the United States.

One of the functions of the Radio Division is to inspect radio apparatus on all vessels leaving American ports. During the year under review the division made 11,334 inspections of this type as compared with 10,715 during the preceding year. Radio installations on airplanes are also subject to inspection by this division. Last year, the report shows, 215 planes, exclusive of those of the Army and Navy, were equipped with radio, as compared with less than 100 for the year 1928–29. In order that life may be properly safeguarded, Mr. Terrell points out, the radio apparatus on passenger-carrying planes should receive the same attention as is now given to the radio equipment on merchant vessels.

All licensed radio stations must be operated by licensed operators, the report explains. The duty of examining and certifying to the qualifications of these operators is one of the functions of the Radio Division. During the last fiscal year approximately 10,000 operators were examined and in addition more than 6,000 licenses were renewed.

Amateur transmitters, the report shows, still continue to play an outstanding role in the development of radio. During the fiscal period reviewed in the report there was an increase of 2,165 amateur stations, making the total number of these stations now operating around 19,000. Considering the restricted wave space allotted to amateurs, Mr. Terrell declares that the progress they have made has been nothing short of phenomenal.

In concluding his report Mr. Terrell states that the rapid development of radio in this country has placed a steadily increasing burden of work on his division. More attention, he declares, should be given to the inspection of broadcasting stations than is possible with the present staff of the division. The information developed by these inspections, he points out, would undoubtedly be of marked value to the Federal Radio Commission in the formulation of its future policies.

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ELECTRAD APPOINTMENT

The progress of Electrad, Inc., in developing their amplifier business has necessitated an enlargement of their technical staff according to a statement by Arthur Moss, president of the company.

Millard Van Blaricom, widely known expert in amplifying systems is now on the technical staff of Electrad, Inc. Mr. Van Blaricom will assist customers in their problems with amplifiers and their application, assuring a close cooperation between the company and its customers.

Standard of Excellence

A phrase synonymous with dependability—a phrase that has come to be applied to all AmerTran Audio Transformers.

Keeping pace with the advancement of broadcasting, reception, and amplification, AmerTran engineers have developed 34 designs of audio transformers. These units represent the best that modern engineering genius can produce with the finest of materials, and are available for every conceivable audio requirement. All radio engineers should have a copy of our general catalog, Bulletin #1000, as a guide in specifying any of the following:

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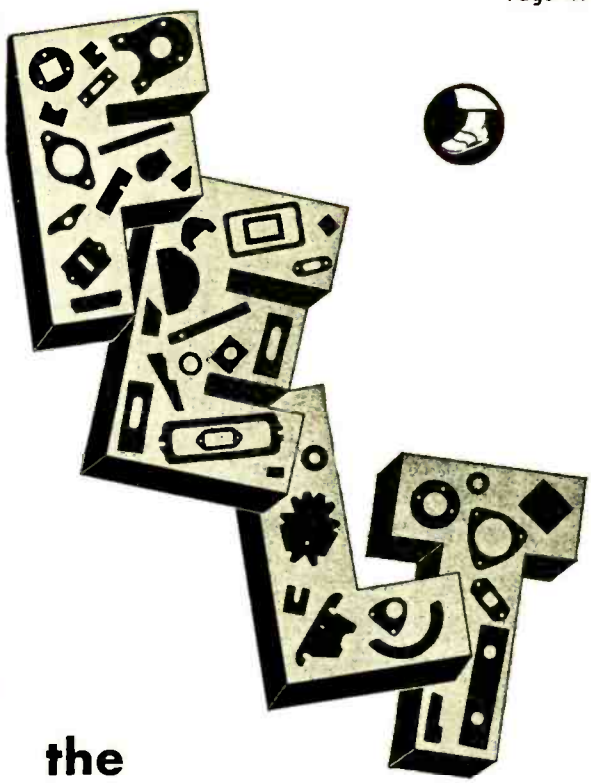

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American Felt Co.

NEW YORK BOSTON SAN FRANCISCO DETROIT
CHICAGO PHILADELPHIA ST. LOUIS

AMERICAN FELT CO., 315 FOURTH AVENUE, N. Y. C.
We are interested in the use of felt.
Send sample for .....
☐ Have your representative call.
Name.....
Address.....
.....

DE FOREST REPORTS ACTIVITY IN TRANSMITTER FIELD

Marked activity in the transmitter field is reported by William J. Barkley, vice-president of the DeForest Radio Company. A considerable amount of floor space is devoted to the production of transmitters and associated equipment, as well as to a complete line of transmitting tubes, in the huge Passaic plant.

"There is a steadily increasing demand for transmitters and transmitting tubes," states Mr. Barkley, "and we are enjoying our just share. Recently, we have completed such transmitters as the 5-kilowatt job for the Michigan State Police, installed at East Lansing. Additional orders for police and municipal radio telephone transmitters are now going through the plant, and more are in prospect. Our radio transmitter business is being handled under the immediate direction of Roscoe Kent, one of the old-timers of the radio industry since his career dates back to prewar days when he was associated with Dr. Lee DeForest in a sales capacity.

"There is also a brisk demand for DeForest transmitting tubes, ranging from the low-power tubes employed largely by the radio amateurs, up to the large water-cooled tubes. Harry C. Gawler, another old-timer, is in charge of our transmitting tube sales. Even during the recent lull in the production and sales of standard receiving tubes, our transmitting tube department has been kept busy with orders received from both here and abroad."

▲

ALUMINUM STOCKS

The Fairmont Aluminum Company announces the appointment of Central Steel & Wire Company of 4545 South Western Blvd., Chicago, Illinois, as its selling agents in the Chicago and middle Western territory, effective January 1, 1931.

The Central Steel & Wire Company will at all times carry a complete warehouse stock of all gauges, sizes and tempers of bright flat sheet, grey plate and aluminum coils. Their warehouses are located in Chicago, Illinois, Detroit, Michigan and Dayton, Ohio.

Other warehouse distributors of Fairmont Aluminum Company are: Chas. A. Strelinger Co., Detroit, Michigan; J. M. & L. A. Osborn Co., Cleveland, Ohio; Ducommun Corporation, Los Angeles and San Francisco, California.

▲

NEW SOLDER LINE

The Kester Solder Company, 4201 Wrightwood Ave., Chicago, report that during the past year in addition to placing the 1-lb. and 5-lb. spools in display packages, they have added various sized spools of paste core solder to the Kester line, for those accustomed to using paste with solder, and have introduced Kester body solders—cored for tinning and solid for filling.

▲

SYNTHANE'S REPRESENTATIVE COMPLETES EXTENSIVE TRIP

J. B. Rittenhouse, vice-president and Chicago representative of Synthane Corporation, Oaks, Pa., manufacturers of Synthane uniform laminated bakelite, has just completed an extensive trip to the company's western representative in San Francisco and Los Angeles.

Synthane Corporation, although a comparatively newcomer in the laminated bakelite field, has grown at a rapid rate, until today its products are used extensively in practically every industrial and manufacturing center in the United States. Synthane laminated bakelite is now being used by electrical manufacturers covering all kinds of electrical apparatus and appliances, radio manufacturers, railroads, power plants, telephone companies, gear cutters and users, textile mills, refrigerator manufacturers, builders and architects and numbers of others.

Synthane Corporation concentrates on manufacturing one product — laminated bakelite in sheets, rods, tubes and fabricated parts. In addition it has perfected a Synthane stabilized gear stock of exceptional merit. The company is a notable example of doing one thing well.

In addition to their representatives in San Francisco and Los Angeles, Synthane has offices in St. Louis, Chicago, Dayton, Boston, New York and their home office at Oaks, Pa., near Philadelphia.

▲

INSULATED ALUMINUM WIRES AND CABLES

General Cable Corporation has recently announced a varied line of insulated aluminum wires and cables under the trade name "Alectral." Heretofore, practically all of the aluminum used in the transmission of electrical energy has been in the form of bare conductors. Its use for this purpose is well known to the electrical industry, and within the past ten years more than 250,000,000 pounds of aluminum have been employed in the production of overhead transmission lines. The introduction of Alectral wires and cables, representing as it does a new development in the field of insulated conductors, enables the electrical engineer to employ the economic features of aluminum in a much broader field, including magnet wire.

▲

MUTER FORMS NEW COMPANY

The Muter Company has been organized by Leslie F. Muter to take over the Compo Manufacturing Company, and is now established in its new factory at 1255 South Michigan Avenue, Chicago. Greatly increased facilities have been installed to manufacture the popular line of Candohm resistance units which are now standard equipment on a majority of the leading radio receivers. This line will be supplemented with sevral other popular items for manufacturers.

The personnel of the new company will consist of: Leslie F. Muter, president; J. L. McWeeny, vice-president in charge of manufacturing sales; A. A. Dailey, secretary in charge of jobbing sales.

The Muter Company has been admitted to membership in the R.M.A., of which Mr. Muter is a director and chairman of the Credit Committee.

▲

HUM MINIMIZED IN NEW RADIO TUBE

The Arcturus Radio Tube Company, Newark, N. J., manufacturers of Arcturus blue tubes, announces a new Type 124 screen-grid tube that reduces hum to a minimum when operated as a detector in conjunction with high-gain audio-frequency amplifiers. The new 124 has several exclusive and unique features.

The new tube utilizes a patented filament insulation having a remarkably high resistance at high temperatures. This special insulation is free from pores or openings which permit electrons from the heater to escape and cause hum. This new humless tube also has the added Arcturus advantage of 7-second action which has been one of the otstanding features of Arcturus tubes.

Extraneous noises, such as crackling and scratching, due to leakage from cathode to heater are also eliminated in this new tube.

The Engineering Division of the Arcturus Radio Tube Company has, after extensive research and investigation of all methods of filament insulation now in use, developed this advanced tube which has shown up remarkably well under life tests.

▲

VOLT-OHM-METER

The Weston Electrical Instrument Corpn., Newark, N. J., has ready Model 564 a compact and inexpensive test instrument for voltage and resistance measurements and continuity tests.

The simplicity and scope of this small meter makes it suitable for many purposes such as for shop and factory tests, for radio laboratory use, as accessory equipment for servicemen and supervisors, for servicing automobile radio and when used with a special adapter for checking the voltages and continuity of circuits in airplane radio sets after each flight.

Its equipment consists of a Weston d-c. Model 301 with four voltage ranges of 600/300/30/3 volts (all 1,000 ohms per volt) and two resistance ranges of 0-100,000 and 0-10,000 ohms. A self-contained "C" battery is provided and a pair of 30-inch cables with test prods. Any change in potential of the self-contained "C" battery can be readily compensated for by simply short circuiting the posts X-X and adjusting the meter pointer to the zero ohm position by turning the voltage adjuster located at the top of the name plate.

All ranges are brought out to binding posts and two toggle switches are provided, one to connect the meter in circuit as a voltmeter or ohmmeter and the other to change the sensitivity of the instrument from 1 to 10 ma. when using the 100,000 or 10,000 ohm scale. This simplifies checking up trouble in high or low resistance circuits.

The overall dimensions of Model 564 are 5½ x 3⅝ inches x 2⅛ inches deep (excluding binding posts) and the weight is 2.3 pounds including the self-contained "C" battery. Instructions for the use of this volt-ohmmeter are given on the name-plate on the instrument.

▲

SYNTHANE APPOINTS NEW ENGLAND REPRESENTATIVE

Synthane Corporation, Oaks, Pa., manufacturers of Synthane uniform laminated bakelite, have recently appointed George F. Clifford, of Boston, as their New England representative. Mr. Clifford, a man of long experience with electrical and industrial requirements in New England, will have offices at 2 Belton Street, Arlington, Mass.

▲

NEW ELECTRIC DRILL

A new type of electric hand drill that bores with equal facility into wood, metal, and masonry, known as the Wodack electric dual twist and hammer drill, is manufactured by the Wodack Electric Tool Corpn., 4627 West Huron St., Chicago, Ill.

The Wodack dual requires only one minute to drill a 9/16 inch hole 3 inches deep in concrete. In addition to operating as a hammer, it is a highly efficient rotary drill with correct speed and power to provide maximum drilling efficiency over the entire range of sizes from 0 inch to ⅜ inch in metal and ½ inch in wood.

▲

MINIATURE MIKE

Along with the movement for things miniature, the midget mike has come into the field of radio accessories. Universal Microphone Co., of Inglewood, Cal., is producing a baby microphone, with a twenty-five foot extension cord to connect to the home receiver. Complete instructions are sketched and engraved on the reverse side of the microphone and a separate sheet lists instructions for connecting with various sets.

▲

FELT FEET FOR MIDGETS

T. R. Brawley Felt Company, Inc., of 275 20th Street, Brooklyn, N. Y., announce the addition of a midget felt foot to meet the popular demand of a less expensive foot than the standard size used on larger type models.

These feet are ideal for the popular midget sets. They can be quickly tacked to the lower corners thereby preventing scratching of tables or other surfaces and assuring a greater sales appeal for the set.

SOLA voltage compensator

TO THE ENGINEER

. . . . One of the major problems confronting the Radio Engineer has been the regulation of line voltages within limits which will assure satisfactory performance of receivers. The *Sola Voltage Compensator* based on sound *Transformer* principles, was designed to assist the Radio Manufacturer in producing *Quality* reception and affording protection to tubes and condensers by *instantaneous* voltage control.

The high degree of regulation possible with the SOLA COMPENSATOR is *not* dependent upon heat dissipation and can therefore give *immediate* regulation with a *minimum* power loss. This is not possible when ballast tubes or resistance units are employed to regulate voltage.

The Compensator can be constructed to operate at various capacities and with special degrees of regulation.

Write for circular and further technical information.

Other Applications include Television, Photo Electric Cell Equipment, Film Printing Lamps, Synchronous Sound Devices, Relays and Signaling Equipment.

It reduces high incoming line voltages

It increases low incoming line voltages

AUTOMATICALLY *and* INSTANTANEOUSLY

SOLA CORPORATION

2525 CLYBOURN AVENUE CHICAGO, U. S. A.

CROWE

TUNING UNITS DESIGNED TO MEET THE CURRENT DEMAND . . . . .

● The Crowe line of Radio Tuning Devices is well balanced and rounded out to the current needs of the Radio Industry.

In the pages of our new catalog—Bulletin No. 41—are tuning units to fit any type of circuit, from the costliest superheterodyne to the popular-priced midget.

Both of the units shown at the right are made to sell at medium prices. They are designed to meet the needs of current radio models. Both are friction driven, but have different types of control. The No. 35 is driven by a metal belt under tension, while the No. 40 is controlled by a spring friction drive.

Bulletin No. 41 will give you detailed information concerning the many tuning units Crowe has to offer. This book also carries many new escutcheon designs that are available for use with the new tuning units. . . . . Write for this catalog! The coupon below will bring it to you by return mail—and without obligation to you.

CROWE
NAME PLATE & MFG. CO.
1747 Grace Street,
CHICAGO

Send for Bulletin 41

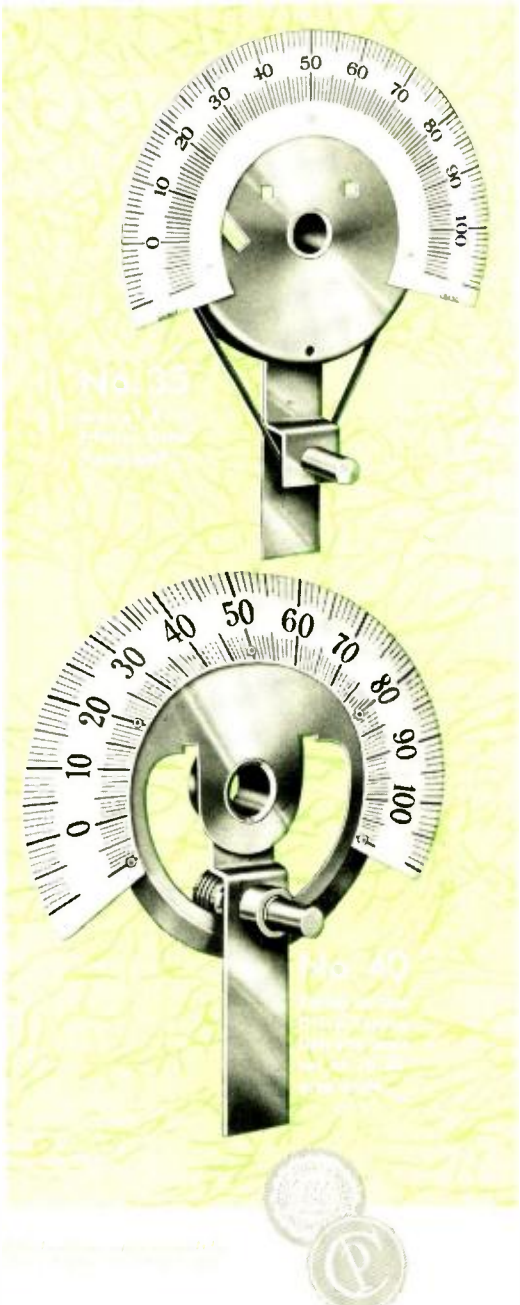
CROWE NAME PLATE & MFG. CO

Gentlemen: Please send me a copy of your catalog of radio tuning devices and escutcheons, Bulletin 41.

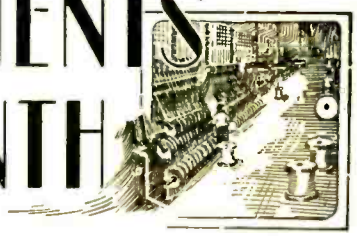
Name _____

Address _____

City _____ State _____



NEW DEVELOPMENTS OF THE MONTH



NEW RHEOSTAT AND POTENTIOMETER

D. T. Siegel, general manager of the Ohmite Mfg. Co., 636 N. Albany Ave., Chicago, announces that two novel features of great practical importance—a percentage-of-resistance scale and a contact-screw—are incorporated in the new Ohmite slide-wire rheostat and potentiometer.

Percentage-of-resistance is indicated by a scale across the top of the frame. This enables the worker to obtain a close approximation of the resistance in the circuit without going to the trouble of removing the rheostat and measuring it on a bridge.

The screw arrangement allows the operator to set the phosphor-bronze spring tightly at any desired point, making certain of accurate consecutive readings. There is no danger of the slide being moved accidentally. An absolute contact can be made certain by means of the screw-pressure, where readings are delicate.

▲

THE ELLIS MODEL 12N TWO-BUTTON HAND MICROPHONES

This two-button hand microphone employs the Ellis adjustable buttons used in the regular broadcast type units. This is in distinct contrast to the flimsy construction employed in the average single-button hand microphone.

The Ellis two-button hand microphone is especially recommended for home recording devices, industrial and home talking picture machines, portable public-address outfits, and in general wherever it is not convenient to use a regular spring-mounted microphone. Each unit is carefully made and individually tested. Size: 6 inches long; head 2 7/16 inches in diameter; 1½ inches thick.

Manufactured by the Ellis Electrical Laboratory, 337 West Madison St., Chicago.

▲

STEPDOWN TRANSFORMERS

The Kenyon Transformer Corporation, 122 Cypress avenue, New York, announces a line of stepdown auto transformers, 220 to 110 volts for use with radio receivers, amplifiers, and similar equipment. These

transformers are particularly suited to adapt standard 110 volt equipment to the existing 220 volt lines frequently found here and in the export field. The transformers are furnished in 50, 100, and 150 watt capacities for use on 50 to 60 cycle lines.

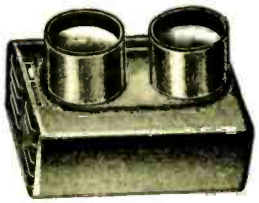
▲

UNIVERSAL MULTIPLE COIL WINDING MACHINE

The Viking Tool and Machine Company, Inc., Belleville, N. J., has ready for sale a new (No. 128) coil winding machine which has various uses in winding coils for radio uses.

PHOTOELECTRIC RELAY

The G-M Laboratories, Inc., Grace and Ravenswood Aves., Chicago, have recently completed the development of a compact photoelectric relay and light source (G-M type No. 1281) for application to many industrial and commercial operations. This device is essentially an electric switch con-



trolled by means of a beam of light. Any interruption of this beam of light operates the switch and will thereby operate or control electrical devices.

The application of this unit is meeting with wide acceptance among industrial and commercial organizations for counting parts on conveyors, inspecting work on presses, operating safety devices, controlling the timing of operations, turning machines on and off, and numerous other operations which can be done more accurately and at much lower cost than by human labor. The use of photoelectric cells will save industry immense sums annually.

▲

TRANSMITTING CONDENSER

The Air-way Condenser Company, 56 Christopher Avenue, Brooklyn, N. Y., is marketing a new Air-Way intermediate transmitting condenser designed to meet the need for a condenser in low power installations where weight and space are essential factors.

They are made entirely of aluminum which accounts for a weight of 3½ ounces for the 50 mmf. size, and 8 ounces for the highest capacity manufactured which is 150 mmf. The space occupied by the latter is 2¾ inches by 5 inches.

▲

ALL-ROUND HAND MICROPHONE

H. E. Billington, general sales manager of the Kellogg Switchboard and Supply Company, Chicago, states that the Kellogg Company has recently placed on the market several new products designed for radio broadcasting, home recording, experimenting, and amateur work. Among these items are a new hand microphone and a modulating transformer which are of special interest.

Mr. Billington states that five of the country's leading radio manufacturers have already firmly established the new Kellogg hand microphone as one of the finest all-round hand sets obtainable, by using it as standard equipment on their home recording sets.

The No. 29 microphone is an entirely new development engineered by the Kellogg Company. It is only 6½ inches in length, small enough to be hidden in the hand, and weighs about 10 ounces. It can be slipped into the pocket easily when it is necessary to carry it. Yet, despite its small size, it is sturdily constructed and reproduces throughout the entire musical scale with the utmost fidelity.

The handle is cast from aluminum with a case of formed brass, combining lightness and strength in its construction to an unusual degree. The back and stretching ring are accurately machined from the finest grade of alloy steel. The diaphragm is made of Kellogg specifications from the best phosphor bronze obtainable.

▲

NEW, COMPACT, LIGHT-WEIGHT CONDENSERS FOR TRANSMITTING AND RECEIVING

The Allen D. Cardwell Mfg. Corporation, 81 Prospect Street, Brooklyn, New York, announces the development of a new type of variable air condenser, both for transmitting and receiving purposes, which will undoubtedly find considerable application wherever extremely light weight and compactness are important factors.

This Cardwell product is known as the "Midway" condenser and can be used advantageously in radio receivers, transmitters and oscillator-amplifier outfits. The Midway transmitting condensers are available in six sizes ranging from 22 mmfds. to as high as 150 mmfds. and having a breakdown rating of 3000 volts. Midway receiving condensers are supplied in seven sizes with maximum capacities ranging from 26 to 365 mmfds.

▲

MICROPHONE AMPLIFIER

The Samson Electric Company, Canton, Mass., has in stock the MIK 100 microphone amplifier.

The new MIK 100 microphone amplifier, together with the PAM 100, make a complete, portable group address system. It can be used at political rallies, church gatherings, in clubs for banquets and social events, in department and retail store demonstration booths.

The MIK 100, alone, forms an ideal unit for remote pickup for broadcast stations.

Football, baseball, and all kinds of sporting events can be picked up without the expense of an elaborate temporary or permanent amplifier installation and without the weight, bulk, and bother of batteries.

Buyers Directory

Manufacturers and engineers who desire information concerning products not listed in these columns are invited to communicate with us and we will advise as to current sources of supply. Kindly address Readers' Information Bureau.

Addresses of companies listed below, can be found in their advertisement—see index on page 66.

ALUMINUM:
Aluminum Co. of America
Fairmont Aluminum Co.

ALUMINUM, SHEET, FOIL:
Fairmont Aluminum Co.
Johnson Tin Foil & Metal Co.

AMMETERS:
General Electric Co.
General Radio Co.
Weston Elec. Instrument Corp.

AMPLIFIERS, POWER:
American Transformer Co.
General Radio Co.
Samson Elec. Co.

ANTENNAE, LAMP SOCKET:
Dubilier Condenser Corp.

BASES, SPEAKER:
American Felt Co.
Western Felt Company

BASES, VACUUM TUBE:
(See Tube Parts)

BINDING POSTS:
General Radio Co.

BRACKETS, ANGLE:
Scovill Mfg. Co.

BRASS:
Scovill Mfg. Co.

BROADCAST STATION EQUIP'T:
American Transformer Co.
Cardwell, Allen D., Mfg. Co.
General Radio Co.
Jenkins & Adair, Inc.
Littlefuse Laboratories
Power Transformer Co.

BUTTS:
Scovill Mfg. Co.

CABINETS, METAL:
Aluminum Co. of America

CASTINGS:
Fairmont Aluminum Co.

CELLS, PHOTOELECTRIC:
National Carbon Co., Inc.

CEMENT, LOUD SPEAKER:
Maas & Waldstein Co.

CENTRALIZED RADIO SYSTEMS:
American Transformer Co.
Samson Elec. Co.

CHASSES:
Aluminum Co. of America
Pierce Airo Inc.

CHOKES, AUDIO FREQUENCY:
American Transformer Co.
General Radio Co.
Meissner Mfg. Co.
Polymet Mfg. Co.
Thordarson Elec. Mfg. Co.

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co., Inc.

CHOKES, POWER:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Polymet Mfg. Corp.

CLAMPS, GROUND:
Clarostat Mfg. Co.
Scovill Mfg. Co.

CLIPS, SPRING:
Electrad, Inc.
Scovill Mfg. Co.

CLOCKS, ELECTRIC:
(See Electric Clocks)

CLOTH, WIRE:
(See Wire Cloth)

COIL FORMS:
General Mfg. Co.
General Radio Co.

COIL WINDING:
Acme Elec. & Mfg. Co.
Concourse Electric Co.
Dudlo Mfg. Co.
Easton Coil Company
General Mfg. Co.
Inca Mfg. Co
Polymet Mfg. Corp.

COILS, CHOKE:
Acme Elec. & Mfg. Co.
Dudlo Mfg. Co
Easton Coil Company
Polymet Mfg. Corp.
Power Transformer Co.

COILS, IMPEDANCE:
Dudlo Mfg. Co.
Easton Coil Company
General Mfg. Co.
Polymet Mfg. Corp.
Power Transformer Co.

COILS, INDUCTANCE:
Cardwell, Allen, D., Mfg Co.
Easton Coil Company
General Radio Co.
Hammarlund Mfg. Co.
Inca Mfg. Co.
Power Transformer Co.

COILS, MAGNET:
General Cable Corp.
Easton Coil Company
Inca Mfg. Co.
Polymet Mfg. Corp.
Power Transformer Co.

COILS, SHORT WAVE:
Easton Coil Company
General Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.

COILS, TRANSFORMER:
Dudlo Mfg. Co.
Easton Coil Company
Polymet Mfg. Corp.
Power Transformer Co.

CONDENSER PARTS:
Aluminum Co. of America
Henry L. Crowley & Co.
Scovill Mfg. Co.

CONDENSERS, BY-PASS:
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co
Igrad Condenser & Mfg. Co., Inc.
Polymet Mfg. Corp.

CONDENSERS, ELECTROLYTIC:
Aerovox Wireless Corp.
Amrad Corporation
Condenser Corp. of America
Polymet Mfg. Co.

CONDENSERS, FILTER:
Aerovox Wireless Corpn.
Amrad Co.
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Corp.
Igrad Condenser & Mfg. Co., Inc.
Kingston Products Corp.
Polymet Mfg. Corp.

CONDENSERS, FIXED:
Aerovox Wireless Corpn.
Amrad Corporation
Condenser Corp. of America
Dongan Electric Mfg. Co.
Dubilier Condenser Mfg. Co.
Polymet Mfg. Corp.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Polymet Mfg. Corp.
Scovill Mfg. Co.

CONDENSERS, MULTIPLE:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.

CONDENSERS, NEUTRALIZING:
Hammarlund Mfg. Co., Inc.
Polymet Mfg. Corp.

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
DeJur-Amsco. Corp.
General Radio Co.
Hammarlund Mfg. Co.
Jenkins & Adair, Inc.

CONDENSERS, VARIABLE:
Cardwell, Allen D. Mfg. Co.
Frost, Herbert H., Inc.
General Radio Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.

CONNECTORS:
Cornish Wire Co.
Scovill Mfg. Co.

CONTAINERS, BATTERY BOX:
George F. Mitchell & Sons Co.

CONTROLS, CURRENT:
Central Radio Laboratories
Polymet Mfg. Corp.
Shallcross Mfg. Co.

CONTROLS, VOLUME:
American Transformer Co.
Central Radio Laboratories
Clarostat Co.
Polymet Mfg. Corp.

CONVERTERS:
Cardwell, Allen D., Co.

COPPER:
Scovill Mfg. Co.

CORDS, EXTENSION:
Anaconda Wire & Cable Co.
Polymet Mfg. Co.

COUPLINGS, FLEXIBLE:
Chicago Gear Works
Hammarlund Mfg. Co., Inc.

CUSHIONS, SPEAKERS:
Aetna Felt Co.
Western Felt Co.

DIALS:
Crowe Nameplate & Mfg. Co.
Hammarlund Mfg. Co.
Scovill Mfg. Co.
United Scientific Laboratories

DIALS, DRUM:
Crowe Name Plate & Mfg. Co.
Hammarlund Mfg. Co.

DIE-CASTINGS:
Allied Die-Casting Corp.

DIES:
Thomas & Skinner Steel Products Co.
Willor Mfg. Corp.

DRYER-IMPREGNATORS:
F. J. Stokes Machine Co.

ELECTRIC CLOCKS:
Electric Clock Corp. of America

ESCUTCHEONS:
Crowe Nameplate & Mfg. Co.
General Etching & Mfg. Co.
Scovill Mfg. Co.

EXPORT:
Ad. Auriema, Inc.

FADERS:
Clarostat Mfg. Co.

FELT, ACOUSTICAL:
Aetna Felt Co.
American Felt Co.
Booth Felt Co.
Western Felt Co.

FELT, PACKING:
Aetna Felt Co.
American Felt Co.
Booth Felt Co.
Western Felt Co.

FILAMENTS:
(See Tube Parts)

FILAMENT CONTROLS, AUTOMATIC:
Amperite Corp.
Polymet Mfg. Corp.

FLEXIBLE SHAFTING
S. S. White Dental Mfg. Co.

FOIL:
Aluminum Co. of America
Johnston Tin Foil & Metal Co.

FUSES, INSTRUMENT:
Littlefuse Laboratories

FUSES, LOW RANGE:
Littlefuse Laboratories

GALVANOMETERS:
General Electric Co.
General Radio Co.
Westinghouse Elec. & Mfg. Co.

GEARS:
Chicago Gear Works

GENERATORS:
Electric Specialty Co.

GETTER MATERIAL:
(See Tube Parts)

GRAPHITE
Acheson Oildag. Co.

GRID LEAKS:
(See Resistances, Fixed)

HANDLING EQUIPMENT:
Nat'l. Vulcanized Fibre Co.

HINGES:
Scovill Mfg. Co.

HORNS:
Amplion Co. of Amer.

INDUCTANCES, TRANSMITTING:
General Radio Co.
Jenkins & Adair, Inc.

INSTRUMENTS, ELECTRICAL:
General Electric Co.
Westinghouse Elec. & Mfg. Co.

INSULATION LAMINATED
Formica Insulation Co.
General Electric Co.
National Vulcanized Fibre Co.
Synthane Corp.

INSULATION, MOULDED:
Bakelite Corp.
Henry L. Crowley & Co.
Formica Insulation Co.
General Electric Co.
General Plastics Co.
National Vulcanized Fibre Co.
Synthane Corp.
Westinghouse Elec. & Mfg. Co.

INSULATION, REFRACTORY:
Henry L. Crowley & Co.

JACKS:
General Radio Co.

KITS, TESTING:
(See Testing Kits)

LABORATORIES, TESTING:
Electrical Testing Labs.

LACQUER, WOOD:
Maas & Waldstein Co.

LACQUER, METAL:
Maas & Waldstein Co.

LACQUER, ENAMEL:
Maas & Waldstein Co.

LAMINATIONS:
Thomas & Skinner Steel Products Co.
Willor Mfg. Corp.

LAMPS, MINIATURE:
National Carbon Co., Inc.

LAMPS, PANEL:
National Carbon Co., Inc.

LEAD-INS:
Clarostat Mfg. Co.
Electrad, Inc.

LOCK WASHERS:
Shakeproof Lock Washer Co.
Thompson-Bremer & Co.

LUBRICANTS, RADIO:
Acheson Oildag Co.

LUGS:
Scovill Mfg. Co.
F. R. Zierick Mfg. Works

MACHINERY, TUBE:
Central Scientific Labs.
Eisler Electric Co.
Int'l. Machinery Works, Inc.
Lepel High Frequency Labs.
New Jersey High Frequency Labs.

MACHINES, SPECIAL
Willor Mfg. Corp.

MAGNESIA, TUBES:
Henry L. Crowley & Co.

MAGNESIUM:
Aluminum Co. of America

MAGNETS:
Thomas & Skinner Steel Products Co.

METALS, RARE:
Fansteel Products Co., Inc.
American Electro Metal Corp.

METERS:
General Electric Co.
Weston Elec. Instr. Co.

MICROPHONES:
Amplion Co. of America
Ellis Electrical Laboratory
Jenkins & Adair, Inc.
Kellogg Switchboard & Supply Co.
Universal Microphone Co.

MOLDING MATERIALS
(See Insulation, Moulded)

MOUNTINGS, RESISTANCE:
Polymet Mfg. Corp.

NAILS:
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PHOTOELECTRIC CELLS:
(See Cells)

PICK-UPS, PHONOGRAPH:
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Jensen Radio Mfg. Co.

PLATES, OUTLET:
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PLUGS, ATTACHMENT:
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Howard B. Jones
Polymet Mfg. Corp.

PORCELAIN TUBING:
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POTENTIOMETERS:
Clarostat Mfg. Co.
Central Radio Laboratories
General Radio Co.
Polymet Mfg. Corp.
United Scientific Laboratories

POWER UNITS, A-:
Thordarson Electric Co.

POWER UNITS, B-:
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General Radio Co.
Thordarson Electric Mfg. Co.

POWER UNITS, A-B-C:
American Transformer Co.
Dongan Elec. Mfg. Co.
General Radio Co.
Thordarson Electric Mfg. Co.

POWER UNITS, PARTS FOR:
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Dongan Elec. Mfg. Co.
General Radio Co.
Polymet Mfg. Corp.
Thordarson Electric Mfg. Co.

PUBLIC ADDRESS SYSTEMS:
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Amplion Corp. of America
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PULLEYS:
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PUMPS, HIGH VACUUM:
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Eisler Elec. Corp.
Int'l. Machine Works, Inc.

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RELAYS:
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The Daven Corp.
DeJur-Amsco Corp.
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Polymet Mfg. Corp.
Shallcross Mfg. Co.
The S. S. White Dental Mfg. Co.
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Easton Coil Co.
Frost, Herbert H., Inc.
General Electric Co.
International Resistance Co.
Polymet Mfg. Corp.
Ward Leonard Elec. Co.

RESISTANCE WIRE:
(See Wire, Resistance)

RHEOSTATS:
Central Radio Laboratories
Clarostat Mfg. Co.
Frost, Herbert H.
General Radio Co.
Polymet Mfg. Corp.

SCREW MACHINE PRODUCTS:
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National Vulcanized Fibre Co.
Scovill Mfg. Co.
Synthane Corp.

SCREWS, HARDENED SELF-TAPPING:
Parker-Kalon Corp.

SCREWS, DRIVE, HARDENED METALLIC:
Parker-Kalon Corp.

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Cochrane Chemical Company

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Radio Products Corp.

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Frost, Herbert H.
General Radio Co.
Howard B. Jones
Soreng Manegold Co.

SOLDER:
Kester Solder Co.

SPAGHETTI:
(See Wire, Spaghetti).

SPEAKERS:
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Jensen Radio Mfg. Co.
Rola Co., The

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TAPE, INDUSTRIAL:
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TAPE, LOUD SPEAKER:
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TESTING KITS:
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TESTING LABORATORIES:
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Power Transformer Co.
Thordarson Electric Mfg. Co.

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General Radio Co.
Power Transformer Co.
Samson Elec. Co.
Thordarson Electric Mfg. Co.

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Dongan Elec. Mfg. Co.
Easton Coil Co.
General Radio Co.
Kingston Products Corp.
Polymet Mfg. Co.
Power Transformer Co.
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See (Machinery, Tube.)

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(See Parts, Tube.)

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(See Testers, Tube)

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De Forest Radio Co.
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National Union Radio Corp.

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National Carbon Co., Inc.
National Union Radio Corp.

TUBES, TELEVISION
See *(Cells, Photoelectric.)*

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TUBING, REFRACTORY:
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Radio Products Corp.

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Fansteel Products Co., Inc.
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Anaconda Wire & Cable Co.
Cornish Wire Co.
Gilby Wire Co.
Radio Wire Corp.
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